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The First Award of the Perkin Medal.

Quod felix faustumque sit. The Perkin medal, founded to commemorate the name of the inventor of mauve, and to act as a powerful stimulus to chemical research and invention, has been awarded for the first time. Mr. J. B. F. Herreshoff, vice-president of the Nicholas Copper Co. and consulting engineer with the General Chemical Co., is the recipient. Almost his whole professional life has been devoted to the furtherance of the interests of the leading chemical corporation of this country and thus indirectly to the progress of American chemical industry. Mr. Herreshoff's achievements in very diverse fields are well summed up in Dr. Chandler's felicitous speech, which will be found elsewhere in this issue. The secret of Mr. Herreshoff's immense success in his profession is to be found in a peculiar and exceedingly rare combination of mechanical engineering ingenuity with chemical science; as Dr. Chandler put it, he is an engineer by birth and a chemist by education—a typical chemical engineer, unsurpassed in his calling. The recognition given to Mr. Herreshoff by his fellow-chemists will give joy to all who believe that the future belongs not to the pure chemist, but to the chemical engineer. The selection of the man to be honored by the award of the first Perkin medal was not an easy one, and a great responsibility was thrust on the committee which made the reward. A number of brilliant names, dear to all American chemists and worthy of the honor, was before the committee, and it is a special pleasure to recognize what a prominent place electrochemical engineers took in this splendid array of names. It should be a matter of congratulation that for some time to come, at least, there will be no difficulty to find men worthy of the honor to receive the medal which bears the beloved name of the founder of the coal-tar industry.

* * *

When Mr. Herreshoff was unanimously chosen as the first Perkin medalist, the leading idea was that in him are incorporated those typical qualities which we hope shall be found in the typical chemical engineer of the future. The name "chemical engineer" is new. It expresses a new idea. Chemical engineers were not recognized in the past. When, through Mr. Carnegie's munificence, the "United Engineers' Building" came into existence, the chemical engineers were not remembered. And yet, after all, there is hardly any industrial development possible without the chemist. That the fault of this lack of recognition of the chemist has been in the past to a great extent with the chemist himself we all agree. That it will be different in the future we all hope. What may be expected of the chemical engineer of the future is exemplified in Mr. Herreshoff. And the award of the first Perkin medal to Mr. Herreshoff will act as a powerful incentive to the growing generation of chemical engineers.

A Mining Technology Branch of the United States Geological Survey.

In the last message of President Roosevelt to Congress the establishment of a Bureau of Mines was recommended as follows: "A Bureau of Mines should be created, under the control and direction of the Secretary of the Interior; the Bureau to have power to collect statistics and make investigations in all matters pertaining to mining, and particularly to the accidents and dangers of the industry. If this can not now be done, at least additional appropriations should be given the Interior Department to be used for the study of mining conditions, for the prevention of fraudulent mining schemes, for carrying on the work of mapping the mining districts, for studying the methods for minimizing the accidents and dangers in the industry; in short, to aid in all proper ways the development of the mining industry." In connection with this movement, looking to the further recognition of the mining industry by the Federal Government, the Senate Committee on Mines and Mining has recently requested the Director of the United States Geological Survey to present his views on the subject. Mr. Smith's report, transmitted to the committee, contains some interesting and important points, to which we wish to call attention.

* * *

The beginnings of Federal investigation of mineral resources are traced back to the early part of the last century, when Lewis and Clark were instructed to pay special attention to the geology and mineral resources during their exploration work. The explorations and surveys which were continued during the first half of the nineteenth century were further recognition of the duty the Federal Government owed the people in making known the resources of the great unexplored western half of the continent. These explorations were particularly actively pushed after the discovery of gold had focussed public attention on the mineral wealth of the trans-Mississippi region. While the results of these various surveys were of inestimable value to the development of the mining interests of the regions which they covered, yet there was lack of co-ordination and an absence of a comprehensive plan covering the entire field. Moreover, it had not yet been recognized as the province of the Federal Government to investigate the resources of the entire national domain, and not simply those of the public lands. In 1866 a more direct attempt was made to aid the mining industries by an appropriation which authorized the Secretary of the Treasury to "collect reliable statistical information concerning the gold and silver mines of the Western States and Territories." Though this investigation received very inadequate financial support, yet the results obtained by Dr. R. W. Raymond were of the utmost value to the mining interests. When, in 1879, the United States Geological Survey was authorized by Congress, all other Federal surveys of a similar character were abolished, and the office of Commissioner of Mineral Statistics under the Treasury Department also lapsed. The organic law provided that the director of the Geological Survey "shall have the direction of the Geological Survey and the classification of public lands and examination of the geological structure, mineral resources and products of the national domain." It is to be noted that this authorization, besides providing for geologic investigation, also directly authorizes the study of mineral resources and the products of the national domain.

* * *

As a matter of fact, the work of the Geological Survey in the past has not been rigidly restricted to geologic investigations, but its directors have taken a broader view of the functions of the Survey, being, of course, limited by the appropriations granted for the work. Mr. Smith points out that while it might be held that the organic authority granted the director, as quoted above, is sufficient for any extension of the mining work, yet, in view of the present well-warranted demand for expansion of such mining work, it seems advisable to secure from Congress specific authorization for these investigations. But, in adequately providing for an increase in the mining work by the Federal Government, care should be taken not to duplicate what is already being done by the Geological Survey. In Mr. Smith's opinion, the whole question resolves itself into that of making adequate provision for the work now conducted by the Technologic Branch of the Geological Survey. These investigations have proved their value, and their scope may well be expanded along technologic lines without duplicating or overlapping the work of other branches of the Survey. The name of the new organization should indicate the restrictions of its functions; it should not be broadly a "mining" bureau, but a "mining technology branch." Director Smith's recommendation is, therefore, either to establish by law a "mining technology branch of the Geological Survey" or an independent "Bureau of Mining Technology," to which the work now under the Technologic Branch of the Geological Survey could be transferred.

* * *

It is open to question whether the surprisingly rapid growth of the Federal Government's ubiquitous activities is really healthy. We are quite sure that if all the recommendations of the functions of the new bureau contained in President Roosevelt's message were carried out, more harm would result than good. For instance, the recommendation to provide "for the prevention of fraudulent mining schemes" is excellent in its intention, but it is hard to see how this can be realized by the new bureau without interfering improperly with sound and legitimate mining enterprises. President Roosevelt's summary of the proposed functions of the new bureau—"in short, to aid in all proper ways the development of the mining industry"—is so broad that it really means nothing. The extension of the scope of the work of the Geological Survey so as to include technology is sound and feasible. But if it is carried out it is of the very greatest importance to prevent any possible friction with the Geological Survey, on the excellent work of which in the past this country may be proud. The safest solution would probably be to establish a Mining Technology Branch of the Geological Survey.

The Chinese Iron Industry.

Much comment was heard last year when 2,500 tons of basic pig iron and later several lots of foundry and pig iron were shipped from China to the United States. It was an exceedingly curious and rare occurrence, quite the opposite of typical. It is not without interest to inquire how it was commercially

possible and practical to make those shipments almost half around the globe, pay a duty of $4.00, and sell the iron in the greatest iron-producing country. Two facts which represent two different sides of the answer are clearly evident: one is the cheapness of shipping by water, the other is the cheapness of Chinese labor. Our readers will find some interesting facts concerning the Chinese iron industry in our present issue in an article of Mr. Blauel, who was formerly connected with the one large Chinese iron and steel plant. To expect competition in this country from the Chinese and Japanese iron steel producers would be ridiculous. But whether the Orient, with its immense natural resources of iron ore and coal in China and with the push and energy of the Japanese, might succeed in getting independent of the American and European iron and steel industry, is a more debatable question. It is not impossible if there really will be a Chinese renaissance, though it seems not very probable at the present time, when we read Mr. Blauel's story of the troubles of the Hanyang Iron & Steel Works, and consider that these troubles were due to the apparently inherent nature and business methods of the Chinese.

Machinery for Chemical Engineering Work.

The article by Dr. Oskar Nagel in our present issue, on machinery and apparatus for melting, heating, dissolving and eluting, is intended to open a serial on the most important machinery, apparatus and devices used in chemical engineering work on a large commercial scale. While the ideal chemical engineer should be a born and trained mechanical engineer, besides being a born and trained chemist, the ideal will be realized only in exceedingly rare instances. But every chemist who has the ambition to become more than a pure analyst, should be fully acquainted with the construction and operation of such machinery and apparatus which are now available for use in chemical works. There is a most essential difference between laboratory work and commercial work on a large scale. In the laboratory the question of cost of the process is almost insignificant; in working on a large scale it is of fundamental importance. Naturally, the machinery and apparatus used in the laboratory and in large chemical works must be very different. In view of the fact that all printed information available in this country on chemical machinery for large-scale operation is scattered throughout various journals and publications of manufacturing companies, we hope that the serial which we start in this issue will prove useful to many.

Weathering the Storm.

The business recession, still marked and unpleasant—in spite of gradually returning confidence in the financial conditions of this country—was expected by all shrewd and cold-blooded observers, but its severity in its acute stage was greater than even the most Cassandra-like prophets foretold. Things in the United States have been "on the boom" with but little breathing spells for nearly ten years. This great expansion caused increases in prices of all commodities and of labor and raised the rate of interest to an extremely high level. Moreover, the efficiency of the workingman and all business was decreased because of the overload. Several things jarred the unstable equilibrium and business reacted. Our rigid and unscientific currency system, the anxiety of a pre-presidential year and social unrest were contributory, but the reaction would have come some time anyhow. Retrenchment and economy are now the order of the day. Laborers are seeking jobs all over the country, instead of the jobs seeking them. Consequently in certain parts of the country wages have been lowered. This is a healthful sign. While we wish to the workingman his fair share in the distribution of wealth, nevertheless the share he demanded previous to the panic, and often seized, was excessive and unfair. We argue high wages for efficiency, but not for inefficiency. The profits of all forms of industry must be reduced. Inefficient plants will be closed. Instead of national extravagance being the order of the day, it will be fashionable to economize. All the time the country will be growing richer, because, though the production of useful articles will be reduced, yet the consumption of these for useless purposes will be decreased, and the annual increment to our real national wealth will be increased. This is as true to-day as it was in the times of Adam Smith. Interest rates will be lowered, and consequently high-grade bonds tend to enhance in value. While this drastic stopping of economic extravagance will not be liked, yet it is a chastening process.

* * *

The indications are that this process will not long continue in America. One reason for this is the curtailment of production of all commodities, especially the metals and their metallic products. The accumulated stocks of these were not abnormally large last Autumn. The partial control of industry in the group of powerful interests in New York will prevent accumulation of commodities to any great degree. For instance, the copper production of the United States, Mexico and Canada is reported as considerably less than in 1906. This, aided by extremely large exportations, is bringing copper into a stronger statistical position. The Steel Corporation, controlling now such an important portion of the pig iron production of the country since its purchase of the Tennessee Coal & Iron Co., is banking a large portion of its furnaces.

* * *

Furthermore, the agricultural West is in good shape with large crops. In fact, it is stronger financially than the East. In 1893, on the contrary, poor crops in a new and unsettled community, with low prices for cereals abroad, had placed the West in a weak position. Finally production of useful commodities is much more efficient now than in 1893, due to the advance of modern scientific methods. It is a case of the survival of the commercially fit. And those plants will live which have been laid out along sound lines. In short, the industry of this country is not in such bad shape as the pessimists would believe. The storm which is still beating strongly on us will leave, when the country weathers it, but little wreckage. For some time, however, most people should work more and spend less. It is rather a pleasant habit when once acquired. For it is none the less true, if it were not so simple, that most things are acquired by a frugality of one's powers and persistence rather than by a burst of enthusiasm and a sprint of success.

The Iron and Steel Market.

The great improvement in the financial situation has produced increased confidence throughout the iron and steel trade, but of actual improvement in demand there has been none.

Production of pig iron during January has been about 35 per cent of normal, and production of steel about 30 per cent of normal. This is an increased rate compared with the holiday week ,but a decrease when compared with the early part of December.

Buying of finished steel products has been purely of a hand-to-mouth character, and has not been sufficient to maintain the rate of production, the latter depending more upon the filling of old orders on which shipment was not suspended. The augury is for some further decrease in production in the near future.

The consuming trade is not greatly interested in the matter of prices at present. There is very little business which would be placed in any event. Producing interests have been working in greater harmony than has ever before been witnessed to maintain prices on finished steel products, but not, as seems to be assumed in some quarters, with the idea that these prices should be maintained indefinitely. On the contrary, producers feel that there should be reductions ultimately, but they do not think the present is an opportune time. They wish, for one thing, to give such a demonstration of strength that when prices are reduced there will be confidence in the new schedule, and besides this they feel that a reduction made now would have to be followed by another later. Whatever statements may be made openly, it is safe to assume that the maintenance of former prices on finished steel products is an evidence that in the inner circles it is not believed that the situation is ripe for a material improvement in demand. It may not be safe to assume the converse is true, that when a general reduction is made it will be evidence that it is believed in the inner circles that conditions are conducive to an important revival.

In the movement which was inaugurated at the Gary dinner on Nov. 20, sub-committees of producers have been appointed in all the important finished steel lines. These committees have been doing missionary work with the view of having prices maintained, and it is the spirit of the times to regard the work as eminently successful. inadequate consideration being given, possibly, to the obvious fact that no serious temptation has arisen to cut prices; that millions of tons of finished steel orders are on the books, awaiting shipping instructions, with the clear prospect that cutting would demoralize the market and write an enormous depreciation upon the value of these orders.

Price Changes.

On Jan. 6 new prices on tin plates and sheet products became effective, the reductions having been formulated by the leading interest and submitted to a meeting of the independents in Pittsburg. These reductions were:

Twenty cents a box on tin plates, to $3.70 for 100-pound cokes.

Ten cents per hundred pounds on black sheets, to $2.50 per hundred pounds for No. 28 gauge.

Twenty cents per hundred pounds on galvanized sheets, to $3.55 per hundred pounds for 28 gauge.

Five cents per hundred pounds on blue annealed sheets, to $1.80 per hundred pounds for No. 10 gauge.

Ten cents per square on painted corrugated roofing, to $1.75 per square for 28 gauge, 2½-inch corrugations.

Fifteen cents per square on galvanized corrugated roofing, to $3.10 per square for No. 28 gauge, 2½-inch corrugation.

These prices are all f. o. b. Pittsburg in carload or larger lots, subject to a rebate of 5 cents per box. hundred pounds or square, under certain conditions; terms, 30 days net or 2 per cent off for cash in 10 days.

These reductions were prompted chiefly by the declines in tin and spelter, such declines being more than sufficient to cover the total reductions made in the coated product. It had been hoped that the tin plate reduction would greatly stimulate buying, but the result has been rather disappointing. There has been a material improvement in buying, but as the coming season is near at hand it is doubtful if this improvement would not have occurred in any event. At the close of January the leading interest was operating about 154 of its 242 tin mills, against an average of about fifty during November and December. The independents, who have about 30 per cent as many mills as the leading interest, have been operating in about the same proportion.

There has been a slight increase in buying of sheet mills products, where but little improvement was looked for.

Ore Prices.

There has been a demand on the part of some furnace interests that prices for Lake Superior ores for the coming season should be announced at once, some of these interests contending that the situation calls for a heavy reduction. The ore interests long ago reached the conclusion that in no event could any large demand be expected for ore this season, and that the condition was opportune to have an off season and get labor in a less intractable mood. They now contend that any reduction in ore prices would write a depreciation on the ores brought down last year and owned by the furnaces themselves. With full production the furnaces provided themselves with ore to lap over the opening of navigation in April, and with the decreased consumption some ore piles may last into August or September. At this writing it appears probable that ore prices will be named within a few days, at substantially the 1907 basis. which was $5.00 for old range Bessemer, $4.20 for old range non-Bessemer, $4.75 for Mesabi Bessemer, and $4.00 for Mesabi non-Bessemer.

Pig Iron.

The movement in pig iron has been small, but rather large in view of the general stagnation, and larger than was generally credited at the time the sales were made. A considerable tonnage of pig iron has been sold at inside prices, the buyer not soliciting competitive bids, but accepting a price from a single producing interest which was from $1.00 to $1.50 below the currently accepted market. Some 30,000 tons or more of Southern iron was sold at $12.00, Birmingham, while at the close of the month the producers insist that the market is $13.00 or $13.50. The central Western furnaces have been quoting $17.00 at furnace for No. 2 foundry, but a few have sold at $16.00. Basic has been available at $16.00 at furnace and Bessemer at $17.

The Southern furnace interests, being self-contained, have been better able to meet the situation than the majority of Northern furnaces, which must buy ore and coke at prices involving good profits to the sellers, so that Southern iron has pushed farther into Northern markets than in the recent past.

Steel.

Prices on billets and sheet bars have been firmly maintained at $28.00 and $29.00, respectively, f. o. b. Pittsburg, but with very light transactions. While these prices are rather high, compared with the reduced prices on pig iron and scrap, it is desired to keep crude steel in line with finished steel.

Finished Material.

The wire interests under date of Jan. 13 announced to the trade that there would be no reductions on wire products for the spring trade. This was interpreted by the trade as a guarantee, and a moderate increase in business has resulted.

A little new structural business has been coming up now and then but has not amounted to one-third the normal.

Plate business has been light, and some of the smaller mills

are shading the recognized market of $1.70 by $2.00 or so per ton. The steel car interests are working on the tail end of their orders, and will probably run out in February, with no prospect of additional orders of consequence.

Iron bars have, as usual, yielded to poor demand and a lower scrap market rather promptly. They have fallen, in different markets, by from 25 to 40 cents a hundred pounds as compared with the prevailing market in October, and are now on the basis of about $1.35, Pittsburg, for Western shipment and on a lower basis than this for Eastern shipment. Steel bars are nominally held at $1.60, the old price, but it is certain that no such basis can be maintained in view of the iron bar situation, and a readjustment in steel bar prices appears merely to await an appearance of actual demand.

COKE.

Contrary to expectations which were entertained in December, the leading Connellsville coke interest immediately after the first of the year announced a reduction in wages, reducing mining and loading room and rib coal from $1.35 to $1.20 per 100 bushels, and other rates in the usual proportions, thus practically restoring the scale which prevailed from March 1, 1905, to March 1, 1907. The lowest scale since the early part of 1899 ruled from Dec. 16, 1903, to March 1, 1905, the mining rate being $1.10. Very little is being done in contract coke; nominal prices for standard Connellsville 48-hour coke are $1.80 to $2.00 for spot and $1.90 to $2.10 for contract, 72-hour coke being $2.35 to $2.50.

Chicago Meeting American Chemical Society.

The thirty-seventh general meeting of the American Chemical Society was held in the Kent Chemical Laboratory of the University of Chicago, Dec. 31, 1907, to Jan. 3, 1908.

On Tuesday morning the American Chemical Society was called to order and the following addresses were delivered:

"The Application of Physical Chemistry to Organic Chemistry." Julius Stieglitz, chairman of Organic Section.

"The Hydronitrogens and Their Derivatives." A. W. Browne, chairman of Inorganic Section.

These addresses were followed by section meetings.

In the afternoon, at 2:30, Clifford Richardson, retiring chairman of Section C of the A. A. A. S., delivered an address, entitled "A Plea for the Broader Education of the Chemical Engineer."

Following this address there was held a special meeting of the Industrial Section, which was well attended, at which the report of the committee on industrial journal and organization of an industrial division was made a special order. The report was discussed at length, and by vote of the section was unanimously and enthusiastically approved by the members present. It was decided to establish a "Division of Industrial Chemists and Chemical Engineers," which shall elect its own officers, and to establish a Journal of Industrial and Engineering Chemistry, covering the whole field of chemical industry, with a Board consisting of an Editor-in-Chief, who shall be a member of the Council, and of twenty-five editors, each an expert in some special field.

In the evening at 8 o'clock, a complimentary smoker to the visiting chemists was given by the local section and some three hundred chemists were present.

On Wednesday, Jan. 1, the Society was called to order in general session, and the reports of committees were made. Marston T. Bogert's re-election as president, and the election of H. P. Talbot, Louis Kahlenberg, Albert E. Leach, Wm. D. Richardson and W. Lash Miller as councilors-at-large were announced.

The meeting then listened to addresses as follows:

"Some Present Day Problems of Biological Chemists." R. H. Chittenden, chairman of Biological Section.

"The Passage of Substances Into the Human System by Osmosis." Louis Kahlenberg.

Following these addresses meetings of the sections were held in adjoining rooms.

In the afternoon, excursions were taken to the Illinois Steel Co., Chicago Gas Light & Coke Co., By-Products Coke Corporation, American Smelting & Refining Co. and the American Linseed Co.

In the evening, President M. T. Bogert delivered his presidential address, entitled "American Chemical Societies," at Fullerton Hall, Art Institute.

On Thursday morning, addresses were made in general session as follows:

"The Non-Equivalence of the Four Valences of the Carbon Atom." J. U. Nef.

"The Chemical Education of the Engineer." Wm. H. Ellis, chairman of Industrial Section.

"Chemistry in the Government Service." W. D. Bigelow, chairman of the Agricultural, Sanitary and Food Section.

"The Inter-Relations of the Elements." Herbert N. McCoy, chairman of Physical Chemistry Section.

Following the general session, meetings of the Sections were held throughout the day.

In the evening at 7 o'clock, the annual subscription dinner was held in the banquet hall of the Auditorium Annex, and was attended by over two hundred chemists and their friends.

On Friday morning, the Inorganic Section finished its program, and in the afternoon, excursions were taken to Swift & Co.'s packing plant, where a complimentary lunch was served; also to Libby, McNeill & Libby's, to the White Lead Co. and to the Standard Oil Co.

Over three hundred and fifty chemists attended the meeting, which was enjoyed by all. The announcement of the rapid and continuous growth of the American Chemical Society, which has now a grand total of 3,567 on its roll, and the plans for special development of its Industrial Section into a Division of Industrial Chemists and Chemical Engineers, with the publication of a Journal of Industrial and Engineering Chemistry, was met with strong approval.

The program of the papers presented before the different sections was as full as usual, their number being not less than ninety, besides the general papers mentioned above. We can mention here only a few. Before the Section of Inorganic Chemistry, J. R. Withrow discussed the influence of temperature on the electrolytic precipitation of copper from nitric acid; C. James, a scheme for the separation of the rare earths; C. R. Sanger, the preparation of silicon tetrachloride. Before the Section on Physical Chemistry, E. P. Schoch spoke on the heat of ionization and the reversible potential of nickel; W. D. Bancroft, on the casting of zinc; C. L. Parsons, on solution in a dissolved solid; J. W. Turrentine, on "reversed electrolysis."

The following papers were presented before the Section of Industrial Chemistry (Wm. H. Ellis, chairman):

W. D. Richardson, "The Criteria of Deterioration in Flesh Foods."

W. D. Richardson, "Transparent Soap: a Supercooled Solution."

C. H. Herty and W. S. Dickson, "The Volatile Oils of Pinus Tæda and of Pinus Echinata."

C. H. Herty and F. B. Stem. "The Use of Carbon Tetrachloride as an Extractive in Commercial Analyses of Cotton Seed Meal."

D. T. Day, "The Examination of Crude Petroleum for Comparative Purposes."

J. E. Teeple, "Long Leaf Pine Oil."

Alfred H. White, "The Microscopic Detection of Free Magnesia in Portland Cement."

W. C. Geer, "The Composition of Wood Turpentine."

W. D. Harknis, "The Deposition of Arsenic upon the Vegetation of Smelter Regions."

American Electrochemical Society.

At the meeting of the board of directors, held in New York on Dec. 27, the following gentlemen were elected members: Dr. Lars William Oholm, University of Finland, Helsingfors, Finland; John L. Polk, Rensselaer Polytechnic Institute, Troy, N. Y.; Dr. Kamejiro Yoshikawa, professor of electrochemistry, Imperial University, Kyoto, Japan; Walter C. Smith, A. C., United States Metals Refining Co., Chrome, N. J.; John B. Lewis, University of Texas, Austin, Tex.; W. H. Erhart, vice-president, Charles Pfizer & Co., New York City; Robert H. Hartley, Hartley Building, Pittsburg, Pa.; Hugo J. Wichmann, United States Food & Drug Inspection Laboratory, St. Paul, Minn.; Herbert A. Baker, American Can Co., Paulsboro, N. J.; Meyer Schamberg, chemist and mining engineer, Philadelphia, Pa.; Wilbur F. Hurlburt, American Electric Furnace Co., New York City; Johan Winsnes, Vadheim Elektro-Chem. Fabrik, Vadheim, Sogne, Norway; Frederick V. L. Hiorth, electrochemical engineer, Christiania, Norway; Lewis E. Saunders, Norton Emery Co., Niagara Falls, N. Y.; James M. Neil, technical chemist, Toronto, Can.; Dr. Franz H. Hirschland, manager, Goldschmidt Chemical Co., New York City; Arthur B. Lamb, associate professor of chemistry, New York University, New York City.

At the meeting of the board, held in Philadelphia on Jan. 28, the following gentlemen were elected members: J. Robert McFarlin, electrochemical engineer, Electric Service Supplies Co., Keokuk, Ia.; Jas. Aston, manager, Thos. Aston & Son, Milwaukee, Wis.; George E. Long, University of Wisconsin, Madison, Wis.; Rudolf Albrecht, The Sun Co., Marcus Hook, Pa.; George R. Kendall, McGill University College, Vancouver, B. C.; Edward Zaremba, manager, American Foundry & Machine Co., Chicago, Ill.; Otto Mantius, American Foundry & Machine Co., Chicago, Ill.; Johan Fr. Irgens, managing electrical engineer, Technisk Bureau, Ltd., Bergen, Norway; Walter H. Aldridge, consulting engineer, Canadian Pacific Railway, Trail, B. C.

International Electrical Exhibition in Marseilles.

An international exhibition of the Applications of Electricity will be held this year in Marseilles, France. It will be opened to the public on April 19, 1908 (Easter Sunday), and will be closed on Oct. 31.

The town of Marseilles, the population of which exceeds 500,000 inhabitants, has now acquired a perfect system of distribution of electrical energy. Furthermore, the entire southeast district of France, which hitherto received its electrical supply from a number of small power stations, will now enjoy the advantages of a vast system of distribution of electrical energy, consisting of a series or ring of hydro-electric generating stations, which when completed, with reserve stations, will have a total capacity of 150,000 hp. Eight departments, including 400 districts, and representing a population of more than 3,000,000 inhabitants, are, or will shortly be, supplied with electricity by this system of distribution.

As a result of these conditions the inauguration of an International Exhibition of the Applications of Electricity, to take place in Marseilles in 1908, has been suggested as a most desirable means to bring to the attention of the general public the numerous possible applications of electricity all grouped together in one general exhibition, and to establish new commercial relations in this vast area, and thus make possible its rapid development by the substitution of new methods for old ones.

The town of Marseilles, recognizing the great possibilities of such an undertaking, has placed the magnificent park of the "Rond Point du Prado" at the disposal of the committee. This park, with a superficial area of 60 acres, was, in 1906, the site of the brilliant and successful French Colonial Exhibition, and lends itself in every way to the object in view by reason of its facility of access, shady avenues, its "Grand Palais" and its general situation and surroundings.

The existing buildings will be supplemented by a number of new ones, and extensions will be made wherever they will be found desirable to fully meet the requirements of the exhibition.

The exhibition will comprise the following principal sections, which will be further sub-divided into classes:

1. Transmission and Distribution of Electrical Energy.
2. Applications of Electricity to Industries in General.
3. Applications of Electricity to Domestic Industries.
4. Applications to Domestic Economy.
5. Applications to Public and Private Lighting.
6. Applications to Heating and Ventilation.
7. Applications to Machinery for Lifting and Manipulation.
8. Applications to Mines and Quarries.
9. Applications to Traction.
10. Applications to Agriculture.
11. Applications to Military and Naval Engineering.
12. Electrochemistry, Electrometallurgy and Allied Arts.
13. Telegraphy and Telephony.
14. Applications to the Medical and Surgical Sciences.
15. Electrical Instruments for Measurement and Calibration.
16. Raw Materials and Manufactures Used in Electrical Industries.
17. Practical and Theoretical Teaching of the Science of Electricity.

Since the special purpose of the exhibition is the demonstration of the applications of electricity, it does not include a section for the "generation of electricity," but manufacturers will be allowed to exhibit plans, photographs and models of machinery built by them and of generating stations executed under their contracts.

Arrangements have been made by the committee to supply exhibitors with electrical energy, including direct and alternating currents at various voltages and frequencies.

The rules and regulations of the exhibition, including a complete list of the members of the different committees, the rates for space and stalls and the supply of electricity, together with a list of awards, will be forwarded on application to the commissioner for the United States, Mr. Paul Diény, Park Row Building, New York City.

CORRESPONDENCE

A Modification of the Induction Furnace for Steel Refining.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—The article by Prof. H. Wedding in your January issue on the Roechling-Rodenhauser modification of the electric induction furnace for steel refining is very interesting, though it seems questionable to the writer whether this modification will meet with much favor.

In the past few years we have heard much about the induction furnace, and have always been told that its chief advantage consists in the absence of all electrodes which could contaminate the molten metal. Now come Messrs. Roechling and Rodenhauser and make a combined induction and electrode furnace. Do they not thereby give up voluntarily the one big chief advantage of the Colby-Kjellin design?

The use of refractory oxide material (such as used for the filament of the Nernst lamp) for electrodes seems ingenious and the writer expects to hear more of it in future for certain work. It needs, of course, preheating in some way to become a conductor. In this present case this is accomplished by the charge, first heated by pure induction currents.

Pittsburg, Pa. M. M. B.

The Perkin Medal and its First Award

The meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on Jan. 24, was devoted to the presentation of the first Perkin Medal to Mr. J. B. FRANCIS HERRESHOFF.

The program of the evening consisted essentially of two parts. In the first half, after the introductory remarks of the chairman and secretary, different branches of chemical industries were discussed by several speakers from different viewpoints in a general, broad way. The second half of the program consisted of the presentation of the Perkin medal to Mr. Herreshoff through Dr. Charles F. Chandler, Mr. Herreshoff's reply, and concluding remarks by Dr. William H. Nichols. While an account of Mr. Herreshoff's brilliant professional achievements as a chemical engineer will be found below in Dr. Chandler's speech, we will give here concisely the chief data of his life.

Mr. J. B. Francis Herreshoff was born in Bristol, R. I., and is a brother of the well-known yacht designers and builders. He received his college education at Brown University, and in 1870 became assistant instructor in chemistry for two years. After that he was chemist with Prof. Charles A. Seely, in New York, and then chemist for the Silver Spring Dyeing Establishment, and chemist with William M. Habbershaw, at New York. In 1875 he was made superintendent of the Laurel Hill Chemical works of G. H. Nichols & Co. In 1890 he was made vice-president of the corporation of the Nichols Chemical Co. In 1900 he became vice-president of the Nichols Copper Co. and consulting engineer with the General Chemical Co. He still occupies these positions.

* * *

Chairman GEORGE C. STONE, in calling the meeting to order, pointed out that the evening marks an epoch in the history of the section. The Perkin medal is to be given to an American chemist as a recognition for good work done. Sir William Perkin was primarly a scientist, a chemist, but he proved equally great as an inventor, and as an engineer in reducing his invention of the first coal-tar dye to a commercial scale and in financing his commercial work. Any man who will succeed equally well in only one of these different lines deserves our recognition. In Mr. Herreshoff, as the first to receive the Perkin medal, we admire a man of broadest engineering ability and of success in many fields.

J. B. FRANCIS HERRESHOFF.

Dr. HUGO SCHWEITZER then gave a history of the Perkin medal and presented the report of the committee for its presentation. He spoke in eloquent words of the development of the coal-tar industry and its effect on chemical science and of the Perkin celebrations in London and New York in 1906. On that occasion the New York Section of the Society of Chemical Industry decided to commemorate Sir William Perkin's name in two ways, by the foundation of the Perkin Library at the Chemists' Club and by the foundation of the Perkin research gold medal. The Perkin medal committee held its first meeting on Dec. 16, 1907. The names of a number of highly distinguished American chemists worthy of the honor were before them. The committee unanimously selected Mr. J. B. F. Herreshoff as the typical American chemical engineer to be the first recipient of the Perkin medal.

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Prof. M. T. BOGERT spoke on **the stimulus given chemical research and invention by suitable recognition.**

While the conscience of having done something worth while is the finest reward a man can have, public recognition should come too. It acts as a stimulus, as an incentive to do more. The victories of a chemist are often spoken of as victories of peace, but victories of peace are not always peaceful victories. Like the soldier, the chemist has to face many dangers in his research. Even the greatest and most careful chemists have to face this danger. Bunsen lost the sight of one eye. ("Even in such harmless research as food chemistry it sometimes happens at the most unexpected moment that the food chemist himself will explode.") American chemists have now the Nichols medal and the Perkin medal as a stimulus. The presentation of the medal to a man means the approbation of his work by his fellow chemists and fellow scientists. The true philosophical mind works not for gold. He seeks science, which is more precious than any gold.

* * *

Mr. H. A. METZ (the present Comptroller of New York City) spoke on **the services rendered by the chemist in the development of the coal-tar industry.**

In taking a broad view of this subject he pointed out that in giving an account of the services of the chemist in the industry, or better, industries originating in the utilization of the various products contained in the substance known as coal-tar, it is necessary to give a complete history of these industries. It is impossible to separate in any way the scientific and the commercial development, as they are so closely interwoven in the advance made in the manufacture of the various products, whether coloring matters, medicines, technical products or raw materials. The whole displays a system of evolution which we can appreciate more thoroughly than those in some other branches of science, as we have before us the visible results of each step forward in working out the possibilities of the application of trained scientific knowledge to the problems of these industries.

Mr. Metz traced, in a concise sketch, the development of the industry from the early days of Perkin and Hofmann. He showed how the dye-stuff industry was in the beginning located principally in England, as the names of the new colors which appeared from time to time proved; but owing to the advance of technical education in France and later in Germany it soon passed to these countries. The greatest recent development, as a result of chemical research, is the manufacture and sale of synthetic indigo, the research beginning in 1880 (Bäeyer). Carl Heumann in 1890 tried to use a different starting point. The different big German chemical companies took this research up and carried it to final success about 1896. But at that time the most promising method, that of the production of indigo from benzene, as indicated by Heumann, was still impracticable, on account of the unsatisfactory

yields. J. Pfluger discovered that the addition of sodium amide increased the yield sufficiently to make this process of Heumann's the most satisfactory and successful method for the synthetic production of indigo, and it is this process which is now generally used.

The synthetic indigo is now almost exclusively used by the large manufacturing countries of the world, the total consumption of the United States for the year being equivalent to 1 500,000 pounds of 100 per cent indigotine.

While the manufacturers were developing the coal-tar dyestuff they were not idle in other lines, as the list of medicinal chemicals derived from coal-tar shows. Some of the older ones, as antipyrine, acetanilide, phenacetine, "have become so popular as to claim even the attention of the United States Government," but these are only a few of the total number.

This whole development is undoubtedly due to the services rendered by the chemist. Germany has recognized this, and some of the large German companies employ 200 or more research chemists on their staff. "The manufacturing establishments in the United States have begun to employ chemists more and more in their works, and we are here to-night to present this medal which is given as a reward of their labors in this field. If this spirit is encouraged and the use of scientific knowledge increased, the manufacturing interests of the United States will at last take their proper position among the other nations of the world."

* * *

Prof. Samuel A. Tucker spoke on **electricity as applied to industrial chemistry.** The more extensive use of electricity for power purposes in chemical engineering makes it necessary for the chemist to keep abreast of the times and be familiar with the advance of electric power as applied to his own industry. But with the utilization of electricity to produce chemical effects, industrial chemistry is even more deeply concerned, and the industrial chemist or engineer requires at the present time a very broad training in order to fit himself for the many diverse lines with which he may become connected.

The possibilities of electrolytic refining and of electrolytically making substances practically chemically pure in one operation immediately put a premium on the electrolytic article. Such chemicals as caustic soda and cyanide and electrolytic copper may be taken as examples. Metals such as aluminium and calcium and compounds like the persalts are alone possible by electrolytic means. For the purely thermal reactions the use of electricity is particularly advantageous, as a result of the particular features of the electric furnace.

Prof. Tucker remarked how very striking it is to note the rapid introduction into everyday life of material that was quite unknown not so long ago or regarded as a chemical curiosity, and carefully preserved in museums. Carborundum, artificial graphite, silicon, aluminium and acetylene have become such every-day matters that they no longer occasion any remark, but we can all remember when we had none of them.

The high temperature of the electric furnace opens up many new lines of investigation, and one, particularly, of which very little is known. This is the change of state or allotropic modifications that are possible by change of temperature. A piece of lime treated in the electric furnace is thereby changed into crystals of definite form. But the crystalline lime bears little or no resemblance to the ordinary variety except in chemical composition. It no longer slakes in water, even after standing for several days, and can be boiled in hydrochloric acid without action. There are other instances of this phenomenon, but the reason for such a change is not known. We speak of crystalline form, but of the real nature of crystals we probably know as little as of the real nature of electricity.

While the development of applied electrochemistry since the days of Davy and Faraday might appear at first sight to have been slow, we must remember that the electric dynamo and motor had to come before electrochemical engineering could begin. Prof. Tucker traced the rapid development of the last ten or twenty years, and paid attention to the very latest advances in the electrometallurgy of iron and steel and in the fixation of atmospheric nitrogen. He also spoke in most complimentary terms of Acheson's triumph in making deflocculated graphite and entering the vast field of lubrication. "The systematic and clever way in which it was developed only adds to our admiration of its able inventor."

"Really, this ability to invent uses for an invention seems to be peculiar in the electrochemist. The new compound 'monox' seems to place Potter on an equal plane with some others in this respect, for the surprising things that are attributed to that interesting compound remind one of the probable patent claims that the alchemists would have included if patent offices had been in operation in those days."

Electrochemical engineering is peculiarly dependent upon cheap power. "Advantageous as it may seem to obtain power from Niagara the price is too high for the successful operation of many processes of an electrochemical nature, and this is due largely to the heavy outlay necessary for the engineering work which makes the interest charges so great that the price for power must be high. Apparently in this country we have few localities to compare in natural advantages with water-powers which may be found in Europe, and we have the additional disadvantage of high labor cost for the engineering work, so that water power for chemical industries forms in this country a less attractive proposition than at first seemed the case, The location of the available water-power also has a great influence on its usefulness, in connection with transportation facilities, and the proximity of raw material. High-tension power transmission is a help in this connection, but this also adds to the cost of power, which it too high already at the place where it is generated. The use of gas power is extending and will certainly have something to do with the advance in electric iron and steel production."

Professor Tucker concluded his interesting and suggestive speech with this remark: "Inventions come so fast that we are apt to think some problems impossible if they are not solved at once, but when the time is ripe we usually get what we want. It is, therefore, best for the present to content ourselves with such splendid advance as this last branch of chemical industry has had—an advance due to men of the stamp of the one we are honoring to-night."

* * *

Next on the program was a discussion by Mr. James Speyer, of **the chemical industry from the standpoint of the investor.** Mr. Speyer was unable to be present early in the evening, but arrived later and spoke at the session of the Verein Deutscher Chemiker, held after the official program of the evening was over. Though Mr. Speyer's remarks were informal they should be recorded here.

Mr. Speyer first stated that it was hard to discuss the chemical industry from the standpoint of the investor at a time when there were so few investors. Besides Perkin mauve we have now Wall Street blues. So far the chemical industry is very little known in Wall Street, and during the last months this has been a good thing for the chemical industries.

The lessons of the other industries which are better known in Wall Street will be learned, and this will turn out to distinct advantage of the chemical industry. Mr. Speyer concluded with a reference to that well-known fundamental chemical compound, H_2O, and the effect which it has in financiering.

Presentation of the Medal.

Dr. Charles F. Chandler then presented the Perkin medal to Mr. Herreshoff with the following felicitous address:

"It is my privilege as the senior past president of the Society of Chemical Industry residing in this country, to make the actual presentation of the Perkin medal to our distinguished brother chemist, J. B. F. Herreshoff. It seems hardly

necessary, when speaking to an audience of chemists, to enter into any details with regard to Mr. Herreshoff's great achievements in the field of industrial chemistry, but in order to make a record for this occasion, I will take a few moments of your time to give you a brief sketch of some of Mr. Herreshoff's more important labors.

"The improvements and inventions of Mr. Herreshoff began in 1875 and have continued down to the present time—a period of over thirty years. From 1875-1890 he was associated with the firm of G. H. Nichols & Co.; from 1890-1900 with the Nichols Chemical Co., and from 1900 to the present time with the Nichols Copper Co. and the General Chemical Co.

"During these thirty years of active industrial development, Mr. Herreshoff has applied his mind to a very great variety of chemical and metallurgical industries, and has perfected many most radical improvements that have assisted greatly in reducing the cost of production and improving the quality of the products manufactured by these companies.

"He has substituted scientific management for the old-fashioned rule of thumb in the conduct of all the operations which have come under his direction, and has thus developed the highest standard of factory control.

"At an early date Mr. Herreshoff devoted his attention to **copper smelting** and invented the well-known smelting furnace for this metal, which has long borne his name, and was patented in 1883. Prior to this date brick furnaces had been almost exclusively used and the separation of the matte gave very crude and unsatisfactory results. His furnace is steel-enclosed and water-jacketed with a movable fore-hearth or well, placed on wheels, so designed that the slag or the matte running out of the breast of the smelter must pass directly into the hole in the side of the well placed 8 inches or 10 inches below the molten mass that overflows from the opposite side of the well. In this manner the air blast is suitably trapped and coke is prevented from running into the well. The matte, after accumulating in the well, is tapped out from time to time.

"The success of this furnace became generally known and the steel water-jacketed furnace, with a movable well, is now almost universally employed, except where reverberatory furnaces for special reasons offer economical inducements.

"A number of these furnaces have been used in Canada in the Sudbury district for smelting nickel and copper ores. They are also used in the Ducktown district in Tennessee, in Mexico, and have been used for a long time at Laurel Hill.

"Later, Mr. Herreshoff directed his attention at an early day to the improvement of the **chamber process for manufacturing sulphuric acid,** and succeeded in developing the most advanced process that the world has ever seen—at least up to a short time since. In accomplishing this result his ingenuity was taxed in innumerable ways to provide the necessary apparatus with which to put his advanced ideas into practice.

"The atomizers devised by him for the injection of weak sulphuric acid into the chambers were a great improvement and at once reduced the steam consumption one-third. He succeeded in reducing the consumption of nitre to 1 per cent of the sulphur burned.

"He then devised the Herreshoff tower, which is a modification of the Glover tower, and is designed for denitration and for concentration. In place of the brick or self-sustaining walls of the Glover tower, finely crushed material (preferably quartz) is used, and the lateral pressure due to the interior filling or filter bed of the tower is resisted by suitable iron plates outside of the lead sides of the tower. This lining of fine material is thus held suitably in place and is prevented from passing or washing into the filter portion of the tower by an intermediate layer of quartz crushed to sizes from ¼ to ½ inch. The filter bed is sustained by cross-bearers of quartz. The bottom is so constructed that it completely resists the action of very hot acid of very high strength.

"The great advantage of this tower is that its life is exceedingly long. It is nearly indestructible. In operation the heat of the burner gas is retained by having a non-conductor over the arch and this high temperature assists greatly in giving perfect denitration, although the acid is concentrated up to 63° or 64° Be. The acid coming from this tower is so free from iron and alumina that it is run directly into a platinum still or pan, and concentration is completed in another pan constructed of iron, the hot gases from the furnace passing directly under steam boilers. This invention effected a very great saving and has been in use from 1885, to the present time, in the earlier works of the Nichols Co. and in all those of the General Chemical Co.

"Herreshoff then developed an extremely ingenious apparatus for concentrating the sulphuric acid delivered from the Herreshoff tower. The hot acid from the improved tower is first concentrated to 65° in platinum. It is then run into an iron pan for concentration to over 66°. From this pan it runs into a large cast-iron pan, and while passing through it most of it is distilled off and condensed in a platinum Liebig's condenser to 66°. This acid is free from arsenic and otherwise very pure. The acid which passes through the stills without distillation represents a small proportion of the total and has a strength of 98 per cent. The amount of fuel used in the distillation is very small, on account of the small, latent heat of sulphuric acid of this strength. This improvement in the distilling apparatus came as the result of the increasing demand for a purer sulphuric acid than could be obtained by the ordinary methods of concentration. Dr. Lunge, the great authority on sulphuric acid, in his master-work on the subject, states that the claims Mr. Herreshoff made for his still were impossible. Nevertheless, at one single establishment 100 tons of distilled sulphuric acid were produced daily from pyrites, that compared favorably with the concentrated acid made from brimstone, satisfying the demands at the time for purity, at a price at which brimstone could not profitably compete.

"His almost indestructible Glover tower made it possible to concentrate the acid to a much higher strength than had previously been attained. and this in conjunction with the aforesaid stills produced practical results that in the stage of development then existing were almost revolutionary.

"Herreshoff's improvements in the Gay-Lussac towers were also very marked, enabling him to use enormous quantities of sulphuric acid in absorbing, while at the same time the elevation to which the acid had to be pumped was greatly reduced.

"His next invention was patented in 1896, and consists in an improvement on the original idea of the Gilchrist and Johnson type of **roasting furnace;** that is, a roasting furnace intended **for roasting fine iron pyrites ores.** Heretofore a great many roasters had been devised but none of them was satisfactory. Even the Gilchrist and Johnson furnace was a failure on account of inability to make repairs without completely shutting down the furnace, the arms being bolted solidly to the central vertical shaft. This bad feature was overcome by an improvement that made it possible to take out an arm whose teeth were no longer serviceable and replace it by a new one in 1 minute. A marked improvement in this furnace was made and patented by him in 1899.

"When this improved furnace was put on the market there were immense quantities of fines ore in various parts of the country that could not be sold on account of the inability to roast it, especially for sulphuric acid making, without great cost and trouble. This ore was used up very rapidly thereafter, rendering available, say, 3,600 tons a day of fines pyrites, which hitherto had been a kind of drug in the market. When one estimates that this means the production of more than 1,500 tons of sulphuric acid a day, he can see the importance of this furnace to that industry. There must be over a million tons of fines ore roasted in these furnaces annually, or enough to make approximately 2,000,000 tons oil vitriol per

annum. The enormous accumulation of fines ores thus became almost as valuable as lump ore. These furnaces have not only been adopted in a large way by chemical works and fertilizer factories, but also for desulphurizing ores in connection with copper refining. Up to this time there have been sold 478 furnaces in the United States and 644 in Europe, making a total of 1,122 furnaces. Most of these are used for roasting pyrites fines ore in manufacturing sulphuric acid. They have a capacity for burning 3,000 pounds sulphur in 24 hours, and assuming that they were all used in the manufacture of sulphuric acid, the amount of acid produced as O. V. would be about 2,500,000 tons per year. They are still being sold quite extensively in Europe as well as in this country. They have been a great boon to the fertilizer industry of the United States, especially in the South, where most of the pyrites ore is in quite a fine condition when mined. They have also made possible the use of pyrites for the production of paper pulp in place of brimstone, because by their use a sufficiently rich gas can be produced.

"The next great work which Mr. Herreshoff undertook was the development of the **electrolytic refining of copper,** which was at that time practiced in a small way in two different works in the United States. His plan for electrolytic refining was entirely different from anything that had been devised before, or, as I believe, since. The electrolytic refining of copper was not at that time well understood. Even the analytical work necessary was quite inaccurate. The improvements and development which resulted from Mr. Herreshoff's study of the problem were only made possible by the highest scientific attainments and the aid of a corps of men thoroughly trained by him for the work. As a result he has created in the past ten years the largest copper refinery in the world which, in itself, is a clear indication of the fact that his processes have been eminently successful in the perfection of their results as well as in their pecuniary economies. The output of this refinery at the present time is about 1,000,000 pounds of copper per day, or about one-fourth of the world's entire output.

"In connection with this work, Mr. Herreshoff invented an apparatus for casting metal, used especially for the casting of the thin anodes employed in the series system for making electrolytic copper, which has brought about a large saving and which is very extensively used.

"Mr. Herreshoff's crowning achievement has been his work in developing the **contact process for the manufacture of sulphuric acid.** Taking the magnificent work of Dr. Knietsch as a foundation, and the splendid engineering work of the Badische Co., in Germany, Mr. Herreshoff, as the result of more than one thousand investigations, in which he was ably assisted by others, but which he directed, made that process not only adaptable to American conditions, which are quite different from those for which it was originally intended, but has also economized very much the whole cost of the operation, so that now the contact system is an established process in this country. It has made possible the production of sulphuric acid of the highest strength, including anhydrous sulphuric acid, at a lower cost than the old chamber system with the necessary concentrating plants in connection therewith, and now an acid virtually chemically pure can be supplied to the largest manufacturing industries in unlimited quantities at a lower price than previously known.

"In addition to the great achievements which I have already mentioned, there are many others. Mr. Herreshoff has produced almost a revolution in every chemical manufacture which he has undertaken, increasing the yield, decreasing the cost, and improving the quality of the products. One of the great secrets of Mr. Herreshoff's success is his ability to concentrate himself upon any given subject which he has in hand. It is impossible to make a catalog of the achievements of a great man.

"Mr. Herreshoff is an engineer by birth, and a chemist by education. He is a typical chemical engineer, unsurpassed in this calling. It is eminently proper that he should be selected by the representatives of the great chemical societies of this country to receive the Perkin medal, which was founded a little more than a year ago in honor of the great chemist, who laid the foundations of the great coal-tar industries, which have had in the past fifty years such a profound influence, not only upon the chemical industries of the world, but also upon abstract chemical science.

"It gives me great pleasure as the representative of the Society of Chemical Industry and the affiliated chemical and electrochemical societies to place in your hands, Mr. Herreshoff, this beautiful token of the appreciation and affection of your fellow-chemists."

Mr. Herreshoff's Reply.

Mr. J. B. F. Herreshoff replied in a graceful and exceedingly modest speech. He remarked that to succeed in chemistry and its applications one must have great love for his work. He mentioned the words taught him by his old professor in Brown University, "You must love chemistry better than your own soul."

Mr. Herreshoff sketched the benefits which mankind has derived from inventors. In the early ages there was no patent office and no protection of the inventor, and inventions were naturally kept secret and progress was slow. But gradually distinct facts were brought out and they were then formulated into laws. Thus came science into the world. Inventions, improvements of processes, laid the foundation for what is now the glory of the world—science. As it is now, science pays back what it owes to the inventors. It is now impossible to carry out any invention without the aid of science—physical science, chemical science, engineering science. And in spite of all our progress Edison is probably right in saying that we are just only in the beginning and that invention is still in its infancy.

There are two classes of inventors. The first class comprises those who invent something from a theoretical conception, without understanding the difficulties. Their ideas fill the volumes of the patent office, and while most of their work is worthless, much is indirectly valuable for the world, since it acts as an incentive, so that others who understand the difficulties take up the matter again and improve on the imperfections. The second class of inventors are now chiefly connected with our great manufacturing industries. They observe carefully the difficulties which are to be overcome, and by gradual improvement they bring about the most valuable inventions.

Some of these inventions require very little experiment; they come suddenly from an idea. A mere thought brings about at once an important improvement. The Bessemer converter process with its immense commercial importance is an example. In Mr. Herreshoff's own work, when he had installed some roasting furnaces in the South, troubles arose with the shaft and the arms, and letters came and telegrams. This troubled him so much that he concentrated his thought completely on the necessity of making an improvement, and suddenly there came to him the idea of changing the construction to the one which is now so well known. In ten days the construction had been actually carried out, and the parts were on the way to the South. Since that time no further change has been necessary whatever.

In other inventions a great deal of experimenting is required for the development. In Mr. Herreshoff's experience this was specially true in the development of the contact system for making sulphuric acid, with its series of different stages and successive use of different apparatus; cooling of gases, purification of gases, drying towers, the blower, the contact apparatus producing SO_3 and the absorption apparatus. In the first three years of the development of this process in this country there were not less than 1,000 different special

experimental investigations necessary relating to different problems in the different stages. Mr. Herreshoff used this opportunity to express his appreciation to those who had ably assisted him. Without this assistance and without the assistance which comes from a large corporation it would have been very difficult to carry the research to a successful end.

The great advantage which large corporations have is that they can have large laboratories with highly skilled men. Much has been done in this line in Germany, while in this country we must develop to a greater extent this side of our chemical works. We need larger and better research laboratories. Mr. Herreshoff concluded his remarks by expressing the hope that the Perkin medal would act as a stimulus to further progress.

Concluding Remarks.

Dr. WILLIAM H. NICHOLS, president of the General Chemical Co., then made some "concluding remarks," which contained many characteristic and delightfully humorous touches. He said that it was a peculiar pleasure to him personally to be present to-night, since this presentation of the Perkin medal to Mr. Herreshoff was an example and a proof of his (Dr. Nichols') own ability—and that always gave satisfaction. Thirty-five or thirty-six years ago Mr. Herreshoff was sophomore student in Brown University, and as such he was made teacher to the seniors. As Mr. Herreshoff says now, that was the reason why he never graduated from Brown University.

Dr. Nichols then told how in the beginning of his own connection with the chemical industries he had also looked after the scientific end of the work, but then he lost his partner, who had looked more after the business end. Then Mr. Herreshoff came and wanted to be the superintendent. This was in 1875, and Mr. Herreshoff then took over the scientific end of the corporation, while Dr. Nichols became strictly the business man, and that is, said Dr. Nichols, probably the reason "why I do not get the Perkin medal myself to-night."

Dr. Nichols said that his association with Mr. Herreshoff for these many years had been one of the greatest pleasures of his life. He also read a cablegram from London, in which "Lady Perkin and family cordially congratulated Mr. Herreshoff on the reward."

To learn a great lesson we have to consider what encouragement will give the Perkin medal to the rest of us for our work. It is given to somebody who has done something great for the world of chemistry. For this, as Dr. Nichols explained, three characteristic traits are essential for success, and all three are peculiarly embodied in Mr. Herreshoff: first, simplicity of character, without the slightest trace of duplicity; second, modesty; and third, "when you are at work do not think of yourself, but of the result, then the end will be crowned by success."

After the conclusion of the official meeting of the Society of Chemical Industry a session of the Verein Deutscher Chemiker was held in the well-known enjoyable, informal way. Songs and informal speeches held the meeting together until after midnight. Dr. Schweitzer presided.

New York Section American Electrochemical Society.

At a meeting of the New York section of the American Electrochemical Society, held in the Chemists' Club on December 17, Prof. C. F. Tucker being chairman, an interesting sketch of the development of modern electrolytic copper refining was given by Mr. Lawrence Addicks, of the United States Metals Refining Co. (De Lamar Refinery).

The second paper of the evening was presented by Mr. H. Martin on storage batteries. The speaker gave a review of recent developments in storage battery design and illustrated his remarks by a series of lantern slides.

Commercial Methods of Manufacturing Pure Hydrogen.

At the last "Versammlung Deutscher Naturforscher und Aerzte," held in Dresden last autumn, Prof. Dr. Adolph Frank, of Charlottenburg, discussed different methods for manufacturing pure hydrogen and described a new one in which the starting material is water gas.

Pure hydrogen is at present used chiefly as a filling for balloons and for welding purposes. Its suitability as a gas for filling balloons is indicated by the following figures: 1 cubic meter of air weighs about 1,300 grams; 1 cubic meter of illuminating gas weighs 600 grams, and 1 cubic meter of commercially pure hydrogen gas weighs 100 grams.

Concerning the use of hydrogen gas for autogenous welding, Professor Frank pointed out to what extent the application of the oxy-hydrogen flame has grown in recent years, espcially in Europe. Autogenous welding of lead with load by means of an air-hydrogen flame has been in use for a long time. But when pure oxygen became commercially available at a reasonable price, the higher temperature which is obtained with the oxy-hydrogen flame permits in an analogous way the autogenous welding of iron with iron. This method is especially useful for welding iron sheets up to 15 mm. thickness and small pieces of machinery.

If the welding shall be successful, it is of great importance that there is a certain excess of hydrogen in the flame so that no oxide can form, which would spoil the weld. Professor Frank seems to think that other disturbing effects may result under certain circumstances with the oxygen-acetylene flame. The temperature of this flame is considerably higher than that of the oxy-hydrogen flame, but if the process is not carefully carried out there is a possibility that some acetylene gas, which is present in excess in the flame, dissociates at the high temperature in the process with deposition of carbon. The carbon is eagerly absorbed by the surface of the melting iron, and in this way the structure of the iron at the point of welding may be considerably changed. For this reason some people prefer to use the oxy-hydrogen flame, especially for the autogenous welding of thinner iron plates up to 12 mm. thickness, although the theoretical superiority of the acetylene-oxygen flame cannot be denied.

As to the commercial methods for producing pure hydrogen gas, one of the oldest methods is based on the action of acids on metals (iron or zinc), and is still largely used.

In the Russo-Japanese war the action of alkalies on certain metals was made use of in an analogous way. The Russians employed aluminium, but recently metallic silicon has also been proposed for the same purpose.

Further, there is the production of hydrogen by electrolysis, either as the cathodic by-product of other electrolytic processes, or the intentional production of oxygen and hydrogen gases by electrolysis of water.

Finally, calcium hydride CaH_2 produces hydrogen by simple contact with water.[1]

Prof. A. Frank, together with Dr. N. Caro and Dr. A. R. Frank, has undertaken to produce hydrogen from so-called water gas, which is obtained in the well-known way by passing steam over incandescent coal. While this gas mixture consists theoretically of 50 per cent by volume of hydrogen and 50 per cent of carbon monoxide, the water gas produced in actual producers contains other impurities. The gas generated in some well-known producers consist, for instance, of 50 per cent hydrogen, 40 per cent carbon monoxide, 5 per cent carbon dioxide, 4.5 per cent nitrogen and 0.5 per cent oxygen.

Frank and his co-workers had used such water gas as a source of carbon monoxide in order to produce graphite, by

[1] A similar compound, called "hydrone" by the Roessler & Hasslacher Chemical Co., who manufacture it, acts in an analogous way; it is a lead-sodium alloy. A very old method of making hydrogen gas commercially, in use in this country, is by decomposing steam by contact with red-hot iron.

the action of the latter on calcium carbide (concerning this reaction, see our Vol. I., p. 423). They also hoped to make artificial diamonds in this way, but state that they have not yet been successful. They made, however, the observation that after water gas had been passed over heated carbide, the escaping gas was pure hydrogen. This is simply explained by the fact that heated carbine not only reacts eagerly with carbon monoxide, carbon dioxide and oxygen, but also with nitrogen, the latter being bound as calcium cyanamide.

The manufacture of graphite from carbon would, however, be economical only with relatively low prices for carbide, and under present conditions it was evident that in such cases where the chief object is to produce hydrogen, it should be tried to reduce the carbide to a minimum. For this purpose carbon monoxide and carbon dioxide were to be removed from the raw water gas according to well-known older methods by passing the gas over other absorbing agents.

Fritschi and Beaufils had already tried, in the eighties, to make hydrogen gas from water gas by passing the latter through a washing tower filled with cuprous chloride solution Their final product contained about 80 per cent hydrogen, which would not be suitable either for balloon filling or for welding.

Frank and Jacobi recently modified the process by absorbing the carbon dioxide by means of a lime tower and obtained a purified water gas containing about 89 per cent hydrogen, from which only the rests of carbon monoxide, nitrogen and oxygen were to be removed by passing the gas through a retort filled with heated carbide powder. In this way they succeeded in obtaining a hydrogen gas 99 to 99.6 per cent pure and containing only small traces of methane and nitrogen.

Although this result was satisfactory, the purification of the raw gas by means of large quantities of cuprous chloride and the subsequent regeneration of the latter by treatment in vacuo had certain disadvantages for operation on a large scale.

A simpler method was finally found by liquefying the water gas in the well-known Linde apparatus for liquefying gases. Liquid carbon monoxide has about the same vaporization point as nitrogen, namely, —190°, while the vaporization point of liquid hydrogen is at —253°, so that the separation in this case must be even easier than that of oxygen and nitrogen. The energy required for liquefying the gas in this case is, according to calculation, so small that the whole energy can be obtained by burning the separated carbon monoxide in a gas engine, which gives an economically and technically interesting cyclic process.

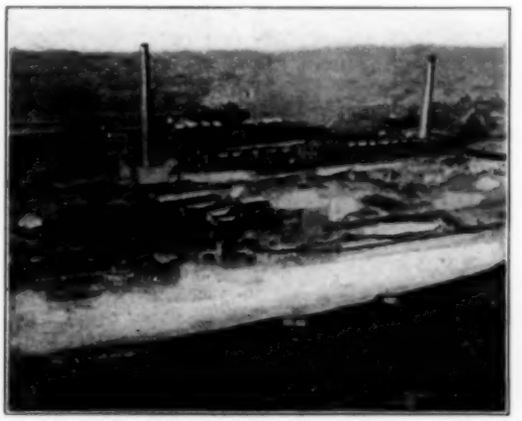
Since laboratory experiments would not give any results useful for the practice, Professor Frank, together with Professor von Linde, has equipped a small, but commercially complete plant, with its own water-gas producer for generating 10 cubic meters of water gas per hour. The results obtained in this plant are to be published later on. Since, according to present experience, the generation of 2,000 cubic meters of pure hydrogen is sufficient for filling three balloons for military purposes, only a single water-gas producer is required. The other apparatus require only small space and little attendance. Besides coke, a moderate supply of carbide is necessary. For a fortress which is being besieged and which cannot get hydrogen gas from outside, this method appears to have great advantages.

Western Association of Technical Chemists and Metallurgists.—The third general meeting of this association was held in Deadwood, S. D., on Jan. 2, 3 and 4. Among the features of this convention were visits to the cyanide mill of the Mogul Mining Co., at Pluma (using the Moore slimes process), to the Homestake mills, to the Homestake filter-press slimes plant at Deadwood, and to the Golden Reward and Imperial Companies' cyanide plants in lower Deadwood. A number of interesting metallurgical and chemical papers were presented, which we will abstract in a future issue.

The Chinese Iron and Steel Industry.

The remarkable fact that last year 2,500 tons of basic pig iron, and later several lots of foundry and pig iron, were shipped from China to the United States, gives considerable interest to an account of the Chinese iron and steel industry, at present practically concentrated in the Hanyang Iron & Steel Works, which we find in *Stahl und Eisen* of Jan. 1, from the pen of a former engineer of these works, Mr. C. Blauel.

The Hanyang Iron & Steel Works are located at the junction of the Han River and the Yangtse River, right near the city of Hankow, which is the greatest and most important commercial center on the immense waterway formed by the

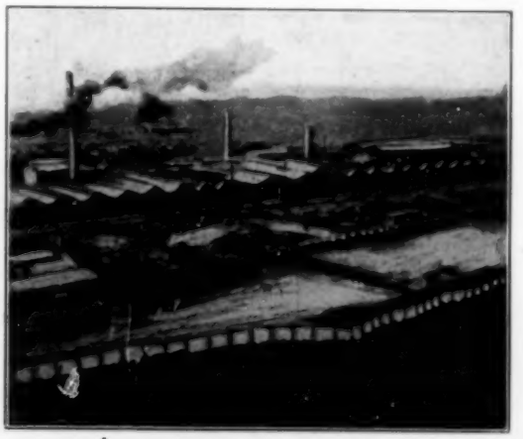


BLAST FURNACE PLANT IN HANYANG (MAY, 1907).

Yangtse River. The distance of the works from sea coast is about 720 miles.

The works were founded in 1891 by the new governor of the province of Hupeh, Chang-Chi-Tung; the plant erected at that time, chiefly under the direction of English engineers, consisted of two blast furnaces, each of 50 tons daily capacity, twenty puddling furnaces, arranged in groups of four, two Bessemer converters, each of 5 tons capacity, one basic 12-ton open-hearth furnace, and two rolling mills, a foundry, etc.

The blast furnaces have been in operation since 1894, but not continually. In the first years only one furnace was generally in operation. By various improvements the daily capacity



STEEL WORKS AND ROLLING MILLS.

per furnace was later on increased to 70 or 100 tons, according to the quality of the pig iron. The puddling furnaces were in operation for only a short period.

The converter plant which received the pig iron, remelted in cupolas, has produced since the end of the nineties chiefly steel for rails of the Hankow-Peking Railroad, which was

built between 1900 and 1905. Besides this, the converter plant and the open-hearth furnace supplied steel to the sheet mills. The yearly output of the rolling mills was hardly more than 15,000 or 20,000 tons and generally much less. In 1896 the works were leased by Governor Chang-Chi-Tung to a Chinese company.

The disadvantages under which the undertaking labored were, in technical respect, inferior coke and, in commercial respect, financial mismanagement by the Chinese managers. At intervals the funds were exhausted, and on one such an occasion, before 1900, the company acting against the advice of its engineers, entered into an agreement with the Japanese government steel works in Wakamatsu, to furnish them for thirty years yearly 100,000 tons of the best magnetic ores, low in phosphorus, at the price of about $1.50 per ton, f. o. b. shipping docks.

This agreement endangered the whole existence of the Bessemer plant, since most of the other available chief ores contained too much phosphorus (0.1 to 0.25 per cent). A great part of the coke also contained small quantities of phosphorus.

In 1904 the works became almost completely the property of the railway director, Sheng-Kung-Pao, and in order to make all magnetic and hematite ores available for working, it was decided to erect a new modern open-hearth furnace plant with large rolling mills, and experts were sent to the United States, England and Germany.

HANYANG IRON AND STEEL WORKS.

The iron ores of the Tayeh district, at a distance of about 60 miles from Hankow, are chiefly red hematite and magnetic iron ore of the following average composition:

58.0 to 68.0 per cent	Fe	0.04 to 0.25 per cent	P
3.0 to 7.0 per cent	SiO_2	0.05 to 0.1 per cent	S
1.0 to 2.0 per cent	Al_2O_3	0.05 to 0.25 per cent	Cu
0.2 to 0.4 per cent	Mn		

There is also found brown hematite containing 6 to 9 per cent of manganese. The deposit of the two chief ores is estimated to amount to more than 100,000,000 tons. They occupy a mountain range of about 7 miles in length. On the side where the iron ore is low in phosphorus, the ore is in contact with limestone, which occurs there in immense quantities as almost pure carbonate of calcium. This district will probably be one of the future centers of the Chinese iron industry, since besides the immense deposits of ore and limestone there is also available good coal suitable for coke making, at a distance of about 18 to 24 miles from the ore deposits.

The new Chinese mining law which was issued in the beginning of November in Peking, does not permit foreign capital to be employed directly in mining in China. Foreigners are only permitted to become stockholders in Chinese companies. If this law should hold, it will take a long time before the Chinese iron industry will flourish. For in spite of the excellent natural advantages of large, good raw materials and easy shipping facilities, very essential changes in the Chinese methods of accounting will become necessary before the investment of money in Chinese mines will assume a promising aspect to the foreign capitalist.

The ore deposit is connected by a 15-mile railroad of normal gauge, with a shipping station on the Yangtse River, from where the ores are loaded on shipboard and carried to the iron works, a distance of about 72 miles. The ores which are exported to Japan are directly loaded into an ocean liner. The loading and unloading are done by coolies, who get 6 cents for 10 hours' work.

The Yangtse River, which is the main waterway of China, and has already an immense traffic, is navigable for the largest ocean steamers up to Hankow from April to October. At Hankow at mean water level it is still almost about a mile wide.

The coal mines near Ping-Hsiang have now been developed so far that a solid coke with about 12 to 15 per cent of ash and 0.8 per cent sulphur is produced. The production is large enough to operate the blast furnaces in Hanyang exclusively with such coke. The difficulty is the necessity to carry the coke by rail a distance of 60 miles and then by water for more than 240 miles. This takes considerable time.

The costs of the raw material per ton, free at the blast furnace, were formerly much higher, but have now decreased to the following values: Ore about 75 cents, limestone 50 cents, coke $6.25 to $7.50, and Ping-Hsiang coal $4.50.

After it had been decided to rebuild the whole works and make them up-to-date, three open-hearth furnaces, each of 30 tons, were bought in the years 1904 and 1906 in England and Germany; further, a gas-fired mixer of 150 tons with gas producer, three large reversing mills and accessories. Electric power is used, and for this purpose a direct-current plant of 800 kw. was installed.

In the beginning of 1907 a third blast furnace for 300 tons daily product was ordered and a fourth and fifth open-hearth furnace, while a second mixer shall be installed later on, also a fourth blast furnace for 300 tons daily output. The old Bessemer plant and the puddling furnaces were dismantled.

At present the two old blast furnaces, which produced daily 70 to 100 tons, the old 12-ton open-hearth furnace and the old rolling mill have been in operation since last year, also part of the electric plant. The new steel plant as well as the new rolling mills was recently set in operation, and it is expected that the third blast furnace will be started before the end of 1908.

All the work of erection was done by Chinamen under the direction of European engineers and foremen. Chinese workingmen are slow and not careful, but the wages are very low. As mentioned above, the lowest class of workingmen, the coolies, get 6 cents for 10 hours' work. Skilled labor gets higher wages. Thus, varying according to experience and age, carpenters and plumbers get $5 to $17.50, machinists and workingmen making installations from $4 to $25 per month (*i. e.*, working twenty-five to twenty-eight times for 10 hours). Foremen at the furnaces, rolling mills and in the workshops get $10 to $47.50 per month. In seaports on the Chinese coast the wages are higher.

Mr. Blauel thinks it is difficult to form a definite opinion concerning the future of the Hanyang Iron & Steel Works. It is certain that the prospects for success are now better than ever before, not only on account of the much better equipment of the works and of the greater experience of the workingmen but because the raw material problem has now finally been regulated.

The steel works and rolling mill output may be 40,000 to 50,000 tons during 1908, if no unexpected difficulties occur. When the third blast furnace has been started, that is in 1909 or 1910, the yearly production may reach 100,000 tons.

Of great importance for the situation is the fact that the present general manager of the plant is Mr. V. K. Lee, who has been for many years in Europe and Japan, and represents the highest and best type of Chinese. The technical management has been always in the hands of foreign engineers and foremen.

Engineers from England, Belgium, Luxemburg, Germany and France come and go, and in most cases, as at present, the engineering staff is international. However, the long tropical summer of the Middle Yangtse Valley renders it difficult for most foreigners to stay for any length of time.

In summer the temperature of the air is for weeks, day and night, above 30° C., rising up to 40° (87° to 104° F.). In July and August even the Chinese find the climate too hot for work, so that in Hanyang it was the custom in the past to stop operation of the steel works and rolling mills for several weeks. With the new improved equipment and better ventilated halls it is hoped that this stopping may be avoided.

The output of the blast furnaces—which in the years 1905 to 1907 was chiefly pig iron for foundry use and steel making and high percentage spiegeleisen—was partly consumed at the plant itself or sold to Japan or to Chinese seaports.

Although the region of the middle and upper Yangtse River has not yet been fully explored with respect to its mineral deposits, yet as far as the results of investigations show there are not only rich metal deposits (gold, silver, copper, zinc, lead, antimony) but also large deposits of coal and iron ores.

Rich iron ore deposits have been definitely located in the provinces of Kweicheou and Kiangsu. Brown hematite containing some 20 per cent manganese is found in large quantities at the Poyang Sea, about 150 miles from Hankow. If the rich iron ore deposits in Shantung, Hunan, Kuangtung, Kuangsi are taken into consideration, and those in Tongking, which now belongs to France, Mr. Blauel thinks that the quantities of iron ore available in China are not much less than those in the United States. While coal for coke making is not available in equal abundance yet there are rich deposits. Most promising for the development of the Chinese iron industry is the district of the Yangtse River, especially on account of the excellent waterway to the coast.

Besides the Hanyang Iron & Steel Works, the Chinese government arsenals, which make chiefly rather inferior guns and cannon, erected open-hearth and crucible furnace plants with rolling mills in Shanghai, Hanyang, Fouchow and Tientsin. Not only did the erection of these works consume a very long time but the operation was stopped after longer or shorter periods, since the experience was always that the best financial balance sheet at the end of the year was obtained when the works did not work.

Some private iron foundries and factories for machinery are found in the larger seaports of China, often in connection with shipbuilding and repair docks. The more important ones are in European hands. During the last years they have had much work on hand but have used exclusively European iron. The wages at these places are very much higher.

Mr. Blauel finally mentions an attempt made in the beginning of the nineties to develop an iron industry in the province of Kweicheow. A small blast furnace with accessories, bought in England, was to be set in operation by Chinese who had studied blast-furnace working for several months in an English plant. They believed they could do the work without the help of foreign engineers, and were, therefore, greatly disappointed when right at starting the furnace the charge froze. Since that time, the furnace, filled with its charge, has been left alone and stands as an interesting document of the abhorrence the Chinese have against foreigners and their art.

While the success of Japan in the last years has undoubtedly had an inspiring influence on China, the internal political situation in China is immensely more difficult and its development will have a great influence on the evolution of industries in China. If industries develop, it may be expected that, as in Japan, this will occur with the use of foreign capital but by Chinese educated in Europe, America and Japan, while the endeavor will be to keep foreigners as much as possible away from the works.

Electrochemical Analysis with Rotating Anodes in the Industrial Laboratory.

II.

By Andrew M. Fairlie and Albert J. Bone.

Methods of Analysis.

In applying the principle of stirring the solution during electrolysis to the estimation of copper in comparatively pure material (such as converter bars), no change in the chemical treatment of the sample from the usual procedure for stationary electrolysis is necessary. Even with impure products, according to our experience, there is only one class of samples—namely, those in which a small percentage of copper is associated with a preponderant amount of iron—requiring any modification of the usual analytical scheme. The deviation from the usual chemical treatment in the analysis of such highly ferriferous samples, though apparently slight and of little moment, is the *sine qua non* for the attainment of uniform and reliable results. What this modification is will appear below.

As hinted in the preceding paragraph, the application of rotating anodes to the analysis of such materials as copper matte and blister copper presented no difficulties, when the apparatus described in the first part of this article[1] was first tried. But it was desired to apply rotating anodes also to the estimation of copper in the daily slag samples. The high percentage of iron in the slags, however (40 to 50 per cent FeO), at first proved an obstacle to permanent deposition. Frequently the copper refused to deposit at all, even after passing a current of 3 amps. for 20 or 30 minutes. At other times, when the deposit did appear with reasonable promptness, it dissolved again, leaving the cathode absolutely bare. Experiments were instituted to investigate the difficulty.

The weight of slag taken as a basis for experimenting was 3 grams. Many different trials were made, varying the amounts of nitric acid and sulphuric acid in the electrolyte. These experiments it is unnecessary here to recount. In most cases, with 2 c.c. or more of nitric acid present in 150 c.c. of solution, the copper, after depositing, redissolved, the following phenomena being, as a rule, observed: About 5 minutes after turning on the current the color of the solution

[1] This journal, January, 1908.

began to darken, and simultaneously a deposit of copper was noted on the cathode. As the current continued to pass the solution became darker and darker, until just about the time the deposition of copper was complete the dark color vanished, and as suddenly the deposited copper redissolved in the electrolyte, which at this juncture gave only a slight test for ferrous iron.

Our experiments have led to the conclusion that the darkening of the solution (which sometimes occurs to a less marked extent even in stationary solutions electrolyzed with a low current) is due to the reduction of iron by the hydrogen liberated by electrolytic action, and to the consequent "brown-ring" reaction with nitric acid. This reduction of iron facilitates the deposition of copper, ferrous sulphate, unlike ferric sulphate, possessing little or no solvent tendency. The continued darkening of the solution is an indication of the gradually increasing quantity of ferrous iron and then of the "brown-ring" compound. The decomposition of this compound $[(FeSO_4)_2NO]$, indicated by the sudden disappearance of the brown color, results in the oxidation of the iron to ferric sulphate, which in turn dissolves the copper on the cathode.

Experiments were made with solutions free from nitric acid —some containing sulphuric acid only, and others sulphuric acid and phosphoric acid; but deposition was slow and the deposits were unsatisfactory. It has been found, however, that by reducing the amount of nitric acid to 1 c.c. for 150 c.c. of electrolyte the copper deposits promptly and also survives the reoxidation of the iron. The same darkening of the solution occurs as when two or more c.c. of nitric acid are present, but with only 1 c.c. the copper does not redissolve when the brown color vanishes. The reason, we conclude, is that with only 1 c.c. HNO_3 in 150 c.c. of electrolyte, less iron is reoxidized, and the concentration of the ferric sulphate is too low to exert solvent action in the presence of the electric current.

If more than 1 c.c. of nitric acid be used, or if more than 3 grams of our slag be taken for a sample, thus increasing the weight of iron in the electrolyte, the bulk of the solution must also be increased to obtain satisfactory results; but this necessitates a longer time for the complete deposition of the copper.

The foregoing observations lead to the belief that in submitting a copper solution to electrolysis, it is necessary to adjust the degree of concentration of certain solvents of copper well within fixed limits, beyond which not only will deposition be greatly retarded, but the copper, once deposited, may even be redissolved, in spite of the continuous passage of the electric current. The solvents most likely to be encountered in industrial practice are ferric sulphate and nitric acid. To determine the solubility of deposited copper, during the passage of the electric current, in these two solvents, cathodes were plated with copper, and were then subjected, while the current persisted, to the action of solutions containing a known amount of iron or nitric acid for a given period, at the end of which the solvents were removed and tested for copper with H_2S water. In making the experiments the following conditions were constant:

Copper deposited on cathode.....	10 mg.
Volume of solution.....	150 c.c.
Temperature of solution.....	52° C.
Duration of test.....	2 minutes.

The quantities required to exert a solvent action are given below:

Anodes.	Amperes.	Present in Solution.	
		Mg. Iron as Ferric Sulphate.	Per cent. by Volume of Nitric Acid (1.42 sp. gr.).
Rotary.....	3.0	703	None
Rotary.....	3.0	None	21.3
Stationary...	0.3	610	None
Stationary...	0.3	None	9.0

Ferrous sulphate is practically without solvent power under the above conditions. Copper deposits were submitted to the action of both rotated and stationary solutions containing as much as 5 grams of metallic iron, as ferrous sulphate, but no action was perceptible.

Lack of spare time has prevented an exhaustive inquiry into all of the mysteries attending the re-solution, in the presence of the electric current, of copper once deposited. The subject is one worthy of careful study by some investigator in a laboratory of pure science, who has the means and the time to delve to the bottom. For ourselves, we must be content with the attainment of our object—the discovery of a practical and reliable method of assaying copper slags with rotating anodes.

Numerous experiments made in this laboratory show that insoluble matter, even as much as 2 grams, suspended in the stirred electrolyte, will not cause low results; but it might lead to high ones, as globules and flakes of sulphur, resulting from the decomposition of sulphide ores, have a tendency to cling to the perforations of the cathode. So far as the weight of the deposited copper is concerned it is entirely permissible to rotate slag solutions without removing the silica, but an objection to such a practice is that the silica somewhat masks the H_2S test for copper.

In electrolyzing copper solutions by means of our octuple rotating apparatus, the following manipulation is involved:

The electrodes are placed securely in position, the anode being inside the cathode. The beakers containing the solutions to be electrolyzed are raised, thus immersing the electrodes, and are supported by wooden blocks. They are then covered with strips of glass provided with suitable apertures for the stems of the electrodes. The motor is started and the current turned on. When the bulk of the copper is deposited the covers are washed off, likewise the sides of the beakers and stems of the electrodes. Electrolysis continues until such a time as experience shows is necessary for complete deposition, but before the cathodes are removed about 1 c.c. is abstracted from each beaker and tested for copper in a porcelain dish with strong H_2S water. As long as any color with H_2S is perceptible, electrolysis is continued. To render this test more delicate in solutions containing much iron, a drop of phosphoric acid may be added to the portion of the solution to be tested, the color caused by the iron thereby being destroyed.

When all of the copper is deposited the motor is stopped, the switch controlling the first pair of electrodes turned, the beaker containing the electrolyte lowered and another containing distilled water quickly substituted. Into this the cathode is allowed to drop, beaker and cathode are removed from the electrolytic rack, and the motor is started to continue stirring the solutions not yet removed. The released cathode is washed in water, three times in alcohol, ignited and placed on a tray. The remaining cathodes are treated in the same way, one after another, but fresh water is provided for the removal of each cathode. It is not advisable to remove a cathode without first stopping the motor, as an appreciable amount of copper is soluble in distilled water when rapidly stirred (if no current is passing), this solvent tendency being greatly enhanced by the small amount of acid solution which adheres to the electrodes when the original beaker is removed. Without stirring, some copper will dissolve in the slightly acid solution, and to a less marked degree in water practically pure, and even in absolute alcohol; such loss, however, is very small and usually negligible. When extreme accuracy is desired the acid solution should be siphoned off and gradually replaced by distilled water before the current is interrupted.

Procedure.

Converter Bars.—Dissolve 5 grams in a 250 c.c. beaker, Griffin shape, with 21 c.c. nitric acid (sp. gr. 1.42), and add 5 c.c. sulphuric acid (sp. gr. 1.84) and evaporate to dryness.

Take up with 75 c.c. water and 2.5 c.c. nitric acid, and boil to dissolve all copper salts. Dilute with water to 150 c.c., and electrolyze with the following conditions prevailing: initial temperature, 50-55° C.; N. $D_{100} = 5$ amps.; time, 2 hours; r. p. m. of anodes, 400-500.

Mattes.—Treat 1 gram in a 250 c.c. beaker with 15 c.c. of a mixture of nitric acid and bromine (prepared by shaking 10 c.c. of bromine with half a liter of nitric acid), and allow to stand a few minutes in the cold until the sulphur is oxidized, adding a few drops of bromine if necessary. Add 4 c.c. hydrochloric acid, boil gently to complete decomposition, and evaporate to fumes with 2 c.c. sulphuric acid. Cool, take up with 50 c.c. water, 2 c.c. sulphuric acid and 2 c.c. nitric acid. Boil to dissolve all soluble salts, dilute to 150 c.c. and electrolyze. Initial temperature, 50-55° C.; N. $D_{100} = 3$ amps.; time, 45-55 minutes; r. p. m. of anodes, 400-500.

Ores.—Take 1 gram and heat gently with 10 c.c. nitric acid until all red fumes are expelled, then evaporate to dryness with 1 c.c. sulphuric acid. Cool, take up with 50 c.c. water, add 3 c.c. sulphuric acid and 2 c.c. nitric acid, boil, and filter into a 250-c.c. beaker. Dilute the filtrate to 150 c.c., and electrolyze. Initial temperature, 50-55° C.; N. $D_{100} = 2$ amps.; time, 40-50 minutes; r. p. m. of anodes, 400-500.

Slags.—Treat 3 grams in a 4-inch casserole with 15 c.c. hydrochloric acid, stir well, add 5 c.c. nitric acid, stir again, cover, and boil for 5 minutes. Remove from heat, slip back the cover a trifle, and add 4 c.c. sulphuric acid. When the violent action has ceased, wash the cover and sides of the casserole, stir the mass well, and evaporate to dense white fumes. Cool, take up with 30 c.c. cold water, add 1 c.c. nitric acid (accurately measured from a burette), boil well, filter, using suction, and wash thoroughly. Transfer the filtrate to a 250-c.c. beaker, dilute, if necessary, to 150 c.c., and electrolyze. Initial temperature, 50-55° C.; N. $D_{100} = 3$ amps.; time, 35-40 minutes; r. p. m. of anodes, 400-500.

The methods outlined above are applied to copper determinations in ores and products remarkably free from interfering elements. Where the latter are present in appreciable amounts certain modifications must be resorted to.

Rotating anodes have been in daily use in the laboratory of the Tennessee Copper Co. for the past eight months. To ascertain the comparative accuracy of the method for slags, check assays were made every day for a period of four months on samples of the two types of blast furnace slags, designated respectively "green ore" and "concentration" slags. The check assays were made on five-gram samples in the following manner: The sample was treated with acids as described above for slags, but instead of adding nitric acid to the filtrate from the silicous residue and electrolyzing it, the copper was precipitated by aluminium and H_2S water, and was then dissolved in nitric acid and electrolyzed overnight in a stationary solution with a low current. The average results for the four months follow:

Type of Slag.	Per Cent. Cu.	
	3 grams Rotated.	5 grams, Stationary.
"Green Ore"	0.270	0.279
"Concentration"	0.648	0.649

Our experience with rotating anodes is limited to copper determinations, and for this work they have certainly fulfilled our expectations. It seems reasonable to assume that other metals, zinc and lead, for instance, may be rapidly estimated on a practical scale by electrolyzing stirred solutions.

Copperhill, Tenn.

Metallic Value of Ores.—A little table, recently issued by the Traylor Engineering Co., of New York City, is very useful, giving a list of the most important ores with percentage of metal contained and specific gravity.

Calculations for Power Plants.

By Dr. Franz H. Hirschland.

Every manufacturer of chemical, mechanical or any other goods has to make himself familiar with the kind of power and power generation which he wants to use in his factory. The success of an enterprise depends, to a great extent, on the price of power. The decision on the location of a plant is not merely influenced by railway connections, source of raw materials, points where to deliver the goods, labor questions, etc., but also to a great extent by the power question. Especially important, of course, is this question in electrochemical enterprises where power is the greatest expense.

To solve the question which kind of power and which kind of power generation is the best and most advantageous one, in a general way, is an impossible task. The items, which have to be considered on answering such a question, change from case to case, and depend not only on the size of the power house, the number of hours which the machines have to run, but also on the voltage which may be required and many other points.

To give a scheme how the power generation question can be solved from case to case, one example is taken in the following and a comparison is set between.

1. Steam.
2. Gas.
3. Hydro-electric power.

It is presumed that a power house of 800 kw., delivering 6,200,000 kw-hours per year, is used for an electrochemical process. The plant having to run about 24 hours per day makes it necessary to devote special consideration to the spare engines.

To give a comparison between the different kinds of power generation, the utility of a plant in a general way, the price of the plant and the price of the current at the switchboard have to be compared.

I. Steam Power.

On deciding on a steam power plant there is the choice of either steam engines or turbines. With regard to the expenses of the plant and economy of the same, both plants are about equally good, but it has to be considered that the high speed of the turbines combined with the low voltage of the dynamo machines required for electrolytical purposes, makes the use of the turbine less advantageous.

Should steam also be required for heating and melting purposes, as it is often the case in electrolytical processes, this can be easier done from a steam engine than from a turbine. With steam engines it is possible to take steam either out of the receiver between high and low-pressure cylinder, or to let one of the steam engines run without condenser, the same working with a certain counter pressure. With steam turbines the same solution would materially affect the economy of the plant.

There being no great difference in price, space and equipment between steam engines and turbines of the required size, the choice remains more a matter of personal taste than of technical advantages.

A condensing plant can be considered in most cases to be economical, at least if a factory site can be located in such a way that there is a sufficient amount of cooling water.

The use of superheated steam for the steam engines would scarcely bring any advantages, as the valves of the Corliss engines, which are most extensively used in this country, would have a tendency to bind. With turbines, on the other hand, the use of superheated steam would have to be very seriously considered.

For both cases a steam pressure of 150 pounds and a vacuum of 26 inches would meet the local requirements.

Assuming the above-mentioned points, the *price of an electrical power station* of 800 kw.. driven by a steam plant, would be, approximately, as follows:

Factory site	$.....
Building with stack	28,000
Steam generators	20,000
Foundation	2,000
D. C. dynamos with switchboard, complete	24,000
Steam boilers, including brickwork, complete	16,000
Condenser, complete	2,000
Pumps, feed-water heater	2,500
Piping, complete	6,000
Traveling crane	6,000
Freight (?)	2,000
Erection of all machinery	6,000
Total cost of installation	$114,500

The consumption of steam for a plant would be about 14 pounds per 1 hp-hour, or about 25 pounds per kilowatt-hour at the switchboard, in which latter amount the consumption of the auxiliaries is included. With an evaporation of 8 pounds of steam with 1 pound of coal of 13,000 to 14,000 B. T. U., 1 kw-hour can be generated with 3 pounds of coal.

The *price of current at the switchboard* is composed as follows:

1. Depreciation and interest—

According to local usage the depreciation and interest, including repairs and insurance, can be put at 14 per cent of the capital amount, which makes per year $16,000

2. The operating expenses are divided into—

A—Labor.

One would require, assuming two shifts, ten men earning per year about 7,400

B—Fuel.

For the generating of 6,200,000 kw-hours, at 3 pounds of coal per kilowatt-hour, 9,300 net tons of coal will be required per year. The different kinds of coal, which can be used for steam boilers, vary greatly in price according to the distance from the mine. Near the mines themselves this coal can be obtained for about $1.25 per ton. Using this lowest figure to calculate on, the coal price would bring up the expenses for this item per year to 11,600

C—Petty Expenses.

Lubricating oil being the principal factor, this expense can be put down at a yearly figure of about 4,000

Drawing all these different expenses together, one finds that with a price of $1.25 per ton for coal the expenses for the generating of 6,200,000 kw-hours during the year are, approximately $39,000

The price for 1 kw-year is therefore $55.20.

II. Gas Power.

The gas engine has in the last few years awakened great interest all over the world.

First-class machine factories have begun the building of these engines, and many special factories already exist which make nothing but producers.

A large field has also been opened for the combustion engine on account of the large available supplies of natural gas. The oil engine is also extensively used for certain purposes.

A—Producer Gas Plant.

Producer gas plants are made both for anthracite and bituminous coal. For soft coal the plants become more difficult to serve and the cleaning of the same is awkward. The price for such a plant is also several thousand dollars higher than for the same with anthracite. The safety factor and economy is in both plants roughly the same. The choice of one or the other can only depend upon the price of coal. Where both sorts of coal are equal in price there could be no hesitation in choosing anthracite.

All firms guarantee 80 per cent efficiency for their producers; that means they can obtain from 1 pound of coal of 13,500 B. T. U. an amount of gas with 10,500 B. T. U. The caloric value of producer gas ranges between 125 and 150 B. T. U. per cubic foot.

The *cost of an electrical power station of* 800 kw., with a producer plant using anthracite coal, would then be as follows:

Factory site	$.....
Building	23,000
Gas engines	55,500
Foundation	7,500
D. C. dynamos with switchboard, complete	24,000
Gas producers	21,000
Foundation	6,000
Compressed air starting apparatus	2,000
Water pumps with electric motor	1,000
Piping, complete	4,500
Traveling crane	6,000
Freight (?)	2,000
Erection of all machinery	7,500
Total cost of installation	$160,000

The price of a similar plant for soft coal would be about $165,000, the higher price being explained by the more expensive producer.

The consumption of coal in a producer plant shows the same to be very economical. The gas engine generates with about 10,500 B. T. U.—one braked horsepower-hour. With an efficiency of the producers of 80 per cent and coal of 13,500 B. T. U., one comes to the result that 1 pound of coal produces one braked horsepower-hour.

One pound per braked horsepower-hour is the claim which all gas engine manufacturers bring against their competitors in the steam engine branch, meaning thereby either a good, soft coal, the size of which is not especially important (as the same binds, anyhow), or an anthracite coal of at least No. 1 buckwheat size; that means a coal which is sieved through netting 9/16 inch diameter. One can safely reckon upon the consumption of 1.9 pounds per kilowatt-hour at the switchboard, including all losses and the auxiliaries.

The *price of current at the switchboard* would be as follows:

1. Depreciation and interest—

14 per cent of $160,000 ..... $22,400

2. Operating expenses—

A—Labor.

Ten men 7,400

B—Fuel.

1.9 pounds per kilowatt-hour, therefore, for 6,200,000 kw-hours, 5,900 tons, at the price of $1.25 7,400

C—Petty Expenses.

(More and better quality of lubricating oil used than with steam engine) 5,000

With coal at $1.25 per ton the entire expenses for generating 6,200,000 kw-hours per year come to $42,200

The *price of 1 kw-year is therefore* $59.60.

The depreciation and interest on gas engines being higher than on steam engines, the consumption of fuel on the other hand, higher with steam engines, gives one a certain coal price at which the generating expenses of both plants are equal.

In the above-mentioned cases this would be at a coal price of $2.18 per ton. If the price of coal is cheaper than this figure the steam engine plant is more economical; with higher prices of coal the gas engine plant is cheaper.

When having to pay a price of $3.00 per ton for coal, as, for instance, in New York and Jersey City, the price of current for a gas engine plant would be about $67.20 *per kw-year*, and for the steam engine about $73.00 *per kw-year*.

In regard to safety and simplicity of regulation, both plants would be about equally good. The fact that one can over-load a steam engine very much more than a gas engine, is not so important in an electrolytic plant on account of the current consumption being particularly constant.

B—Natural Gas Plant.

Natural gas, which is especially well suited for gas engines, is to be had in the States of Pennsylvania and West Virginia. It has a very high caloric value, which can be placed at about 1,000 B. T. U. per cubic foot.

The *price of such a plant* would be, approximately, as follows:

Factory site	$.....
Building	9,000
Gas engines	52,000
Foundation	7,000
D. C. dynamos with switchboard, complete	24,000
Compressed air starting apparatus	2,000
Water pump with electric motor	1,000
Piping, complete	6,000
Traveling crane	6,000
Freight (?)	1,500
Erection of all machinery	7,000
Total cost of installation	$115,500

The consumption of natural gas in a gas engine which can generate 1 hp-hour out of 10,500 B. T. U. would be 10.5 cubic feet per braked horsepower-hour, calculating upon 1,000 B. T. U. per cubic foot. With all losses and reckoning the auxiliaries the consumption would then be about 18 cubic feet per kilowatt-hour at the switchboard.

The *price of the current at the switchboard* would then be as follows:

1. Depreciation and interest—	
14 per cent at $115,500	$16,200
2. Operating expenses—	
A—Labor.	
Six men	4,700
B—Fuel.	
The consumption for 6,200,000 kw-hours at 18 cubic feet per kilowatt-hour is equal to 112,000,000 cubic feet per year. The price varies in the different cities from 4 cents to 20 cents per 1,000 cubic feet. Assuming a price of 4 cents per 1,000 cubic feet, the expense for fuel would be per year	4,480
C—Petty Expenses.	
(Lubricating oil, etc.)	5,000
Total expense, therefore, for the generating of 6,200,000 kw-hours per year with natural gas, at a price of 4 cents per 1,000 cubic feet, would then be	$30,380

The *price of 1 kw-year is* $42.90.

This price is comparatively low. The engine can also be considered as perfectly reliable. The only question is whether the flow of gas can be entirely relied upon or not. The difficulties which arise therefrom can be partially overcome by placing the plant as near to the natural gas well as possible, as the flow of gas is mostly disturbed through breakage and repairing of the gas pipes. In many parts of West Virginia the gas wells are considered to be inexhaustible, and especially so in Clarksburg and Fairmont, where gas at a price of 4 cents per 1,000 cubic feet can be obtained, and which cities are situated in the midst of great bituminous coal mines. At all events, it is advisable to consider the possibility of a failure, or at least a reduction of the pressure in the supply of natural gas, and it should be stated at this point that the alteration of a plant for natural gas into a producer plant is, under all circumstances, feasible.

Producer gas having a much smaller caloric value than natural gas, will make it necessary, in converting one plant into the other, to make certain alterations in the engines. The simplest method would be to alter either the mixing valves for gas and air or the compression. In this case the output of the machines would be reduced by about 20 per cent on account of the low caloric value of the gases. The dynamo machines would also be not used to their full load, and one would therefore require a new unit in order to attain the same current as formerly.

For this reason many firms recommend the use of new cylinders, retaining the frame, fly-wheel and all other parts, though some manufacturers think that the same effect could be reached by reboring the cylinder to 1 inch more in diameter and using new pistons.

C—Oil Plant.

For small plants, or in places where there is little room available, the oil engines can be used with advantage, especially as one saves the space necessary for a producer or boiler. Up to now, engines have not been built for more than a 150-kw., so that for this special case one would require 7 units, counting in two spare engines.

The *price of such a plant* would be approximately as follows:

Factory site	$.....
Building	14,000
Seven oil engines	104,300
Foundation	8,000
Seven D. C. dynamos with switchboard, complete	28,350
Compressed air starting apparatus	2,000
Water pumps with electric motor	1,000
Piping, complete	5,350
Traveling crane	6,000
Freight (?)	2,000
Erection of all machinery	10,000
Total cost of installation	$181,000

The oil consumption would be 1 pound per braked horsepower-hour, which comes to about 1.6 pounds per kilowatt-hour at the switchboard, all losses and auxiliary machinery included.

The *price of the current at the switchboard* would then be as follows:

1. Depreciation and interest—	
14 per cent of $181,000	$25 300
2. Operating expenses—	
A—Labor.	
Six men	4,700
B—Fuel.	
The consumption of 1.6 pounds, or 0.21 gallon per kilowatt-hour would be for 6,200,000 kw-hours per year, 1,300,000 gallons, costing with the price of oil at 2 cents per gallon	26,000

C—Petty Expenses.

(Lubricating oil.) 5,000

The total expenses for 6,200,000 kw-hours per year with an oil-engine plant would be, with oil at 2 cents per gallon, about $61,000

The *price per 1 kw-year would therefore be* $86.00.

This price per kilowatt-year, calculating upon an oil price near the points of production, is so high that the use of the oil engine cannot be considered in this problem, especially as the price of the oil in the East is double that quoted.

III. HYDROELECTRIC POWER.

Though the direct use of turbines and water power is uneconomical in very small plants, the same becomes a most important factor if it is worked on a large scale, as, for instance, at Niagara Falls. In the big turbine plants very high voltage alternating current is generated, which is especially adaptable to the transmission of energy.

For our purpose it would therefore be necessary to transform the alternating current into a direct current of 150 to 200 volts. A rotary converter would be the simplest method of solving this problem, but in consideration of the great difference in voltage on both sides of the machine it will be better in this case to use a motor generator. This plant shall consist of 2 units, as a spare unit may not be needed in such a simple plant.

The approximate *price of such a plant* would then be as follows:

Factory site	$.....
Building	7,000
Motor generators with switchboard, complete.	30,000
Foundation	1,400
Freight (?)	400
Erection of all machinery	2,000
Total cost of installation	$40,800

The efficiency of the plant could be taken at about 0.87. The *price of the current at the switchboard* would then be as follows:

1. Depreciation and interest—
14 per cent of $40,800 ..... $5,700

2. Operating expenses—

A—Labor.

Two men 1,600

B—Current Consumption.

The lowest price of 1 hp-year, which may be offered at the present time, is $16.00; 6,200,000 kw. per year, or 1,100 hp-year, will represent 17,600

C—Petty Expenses.

(Lubricating oil, etc.) 1,000

Total expense, therefore, for a plant of 6,200,000 kw-hours per year, at a price of $16.00 per horse-power-year, would then be $25,900

The *price for 1 kw-year would, therefore, be* $36.60.

This is the lowest price for electric current which we can obtain. An electrical power plant containing a motor-generator can be considered as the most reliable method of generating current for continual service. The cleanliness and easy control of the power plant are an advantage, and the small yearly expense for repairs and renewals is well known. The cost of installing such a plant is considerably lower than that of any other, and the small amount of space required is remarkable.

Metallurgical Calculations.

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The Metallurgy of Lead.—II.

The principal operations in the metallurgy of lead are the roasting of the ore, its reduction to metal and the refining of the crude metal.

Roasting of Lead Ores.

The chief ore of lead being galena, PbS, the operation of roasting it in air converts it partly into PbO and partly into $PbSO^4$. Since PbS is easily fusible, and is volatile *per se* at a yellow heat, it is necessary to roast carefully and slowly, avoiding high temperatures, which first make the ore sticky or pasty and afterwards fuse it, thus practically stopping the roasting reaction. The only manner in which rapid roasting can be done is by having the ore mixed with so much infusible inert matter, like lime, that the globules of melted sulphide cannot run together, but are kept isolated and continue to oxidize on their surfaces, the mass being meanwhile kept "open" or porous by the inert, infusible material, to allow the rapid passage of air through the mass. This is the principle of "pot roasting"—the most radical improvement of recent years in the metallurgy of lead.

Problem 122.

A Savelsberg "pot roaster" treats 5 tons of ore mixture, consisting of 100 parts lead ore, 10 parts quartzose silver ore, 10 parts spathic iron ore, 19 parts limestone. The lead ore is galena ore, containing 78 per cent of lead and 15 per cent of sulphur; the silver ore may be called silica sand; the spathic iron ore $FeCO^3$; the limestone $CaCO^3$. The mixture is moistened with 5 per cent of its weight of water. Air blast is kept constant at 7 cubic meters per minute, blower displacement at 15° C., and the operation lasts 18 hours, leaving 2 per cent of sulphur in the product, which may be assumed as undecomposed PbS. Gases produced contain approximately 10 per cent of SO^2 and 5 per cent free oxygen; 50 kg. of charcoal is used to start the operation, and is assumed to be pure carbon.

Required:

(1) The weight of product and its percentage composition.

(2) The complete analysis of the gases escaping.

(3) The efficiency of delivery of the blower.

(4) The proportion of the heat generated by the oxidation of the ore which is absorbed in the decomposition of the limestone.

(5) The proportion of the heat generated in the pot used in evaporating the moisture of the charge.

TABLE SHOWING COMPARATIVE RESULTS.

	Steam.	Produced Gas.	Natural Gas.	Oil.	Electricity.
Total cost of installation	$114,500	$160,000	$115,500	$181,000	$40,800
OUTPUT IN KW-HOURS PER YEAR 6,200,000					
Fuel or energy required for 1 kw-hour at switchboard	3 lbs. of coal.	1.9 lbs. of coal.	18 cu. ft. of gas.	0.21 gal. of oil.	1.54 hp-hour
Lowest obtainable price of fuel or energy	$1.25 per ton.	$1.25 per ton.	$0.04 per 1000 cu. ft.	$0.02 per gal.	$16 per 1 hp-year.
Fuel cost or energy cost per year	11,600	7,400	4,480	26,000	17,600
Labor per year	7,400	7,400	4,700	4,700	1,600
Petty expenses per year	4,000	5,000	5,000	5,000	1,000
Depreciation and interest per year	16,000	22,400	16,200	25,300	5,700
Total cost of current at switchboard (6,200,000 kw-hours)	39,000	42,200	30,380	61,000	25,900
Cost of current per kw-year	55.20	59.60	42.90	86.00	36.60
Comparative cost of current with electricity at 100	151	162	117	235	100

(6) The proportion of the heat generated in the pot carried away by the gases at an average temperature of 300° C.

(7) Make a heat balance sheet of the whole operation.

Solution:

(1) The components of the 5-ton (= 5,000 kilos) charge are:

Galena	3597 kg.	= Pb:	2806 kg.	S:	540 kg.
Silver ore.....	360 "	= SiO^2:	360 "		
Iron ore.....	360 "	= FeO:	224 "	CO^2:	136 "
Limestone....	683 "	= CaO:	382 "	CO^2:	301 "

Approximate composition of product:

PbO.....	$2806 \times \frac{223}{207}$	= 3023 kg.
SiO^2.....		= 360 "
FeO.....		= 224 "
CaO.....		= 382 "
		3989 "

But, since product contains 2 per cent of sulphur as undecomposed PbS, the above weight is only 99 per cent of the weight of the roasted ore, because the lead combined with this sulphur has been calculated above to PbO, and the O in PbO is only half the weight of the S in PbS. The above weight is short, therefore, by an amount equal to one-half the weight of the sulphur present, and since the latter is 2 per cent of the roasted ore the above weight is 1 per cent short. The corrected weight of the roasted ore is, therefore,

$$3,989 \div 0.99 = 4.029 \text{ kg.},$$

and its sulphur content 81 kg., corresponding to 521 kg. of lead, or 602 kg. of PbS. This leaves present, as PbO, 2,806 — 521 = 2,285 kg. of lead, equal to $2,285 \times 223/207 = 2,461$ kg. of PbO.

Revised composition of product:

PbO.....	2461 kg.	= 61	per cent.
PbS.....	602 "	= 15	"
SiO^2.....	360 "	= 9	"
FeO.....	224 "	= 5	"
SaO.....	382 "	= 9	"
	4029 "		(1)

(2) The charge gives to the gases

H^2O	5000×0.05	= 250 kg.
CO^2	$(50 \times 3.67) + 136 + 301$	= 620 "
S	$540 - 81$	= 459 "

and the blast gives to the charge

O $2461 - 2285 = 176$ kg.

The volume of SO^2 produced from 459 kg. of sulphur, which makes 918 kg. of SO^2, will be, at standard conditions,

$$918 \div \left(0.09 \times \frac{64}{2}\right) = 319 \text{ cubic meters.}$$

The free oxygen in the gases is half the volume of the SO^2, and, therefore, will be exactly one-quarter of its weight.

The volumes of H^2O and CO^2 present in the gases, at standard conditions, are

$$H^2O \quad 250 \div \left(0.09 \times \frac{18}{2}\right) = 309 \text{ cubic meters.}$$

$$CO^2 \quad 620 \div \left(0.09 \times \frac{44}{2}\right) = 313 \text{ " "}$$

The nitrogen present is that in the air used, or 10/3 the weight of oxygen in the air. The latter is the weight of oxygen in the PbO of the roasted charge, plus the oxygen necessary to burn the 50 kg. of charcoal, plus the oxygen oxidizing sulphur to SO^2 and the free oxygen in the gases.

O in PbO.....		= 176 kg.
O to burn C.....	$50 \times \frac{32}{12}$	= 133 "
O to burn S.....	$459 \times \frac{32}{32}$	= 459 "
Free O^2 in the gases.....		= 230 "
	Total	998 "
N^2 corresponding.....		= 3327 "

Composition of escaping gases:

				Per Cent.
Nitrogen.....	3327 kg.	= 2609 cu. meters	=	70.3
Oxygen.....	230 "	= 159 " "	=	4.3
SO^2.....	918 "	= 319 " "	=	8.6
CO^2.....	620 "	= 313 " "	=	8.5
H^2O vapor.....	250 "	= 309 " "	=	8.4
	3709			100.1 (2)

(3) Oxygen delivered by blast..... 998 kg.
Nitrogen in the blast..... 3327 "

Air delivered..... 4325 "

Volume at $0° = 4325 \div 1.293 = 3345$ cu. meters.

Volume at $15° = 3345 \times \frac{288}{273} = 3529$ " "

Displacement of blower at 15°
$7 \times 60 \times 18 = 7560$ " "

Efficiency of blower $\frac{3529}{7562} = 0.467 = 46.7$ per cent. (3)

(4) The heat generated in the oxidation of the ore consists of the heat of formation of the PbO formed, plus that of the SO^2, and less that of the PbS decomposed. This is not the complete heat balance of the whole operation, but simply that concerned with the oxidation of the galena.

Heat of oxidation of Pb to PbO
2285 kg. Pb. × 245 = + 559,825 Cal.
Heat of oxidation of S to SO^2
459 kg. S × 2164 = + 993,275 "
Heat of formation of PbS decomposed
2285 kg. Pb × 98 = − 223,930 "
Roasting heat = +1,329,170 "

The decomposition of the limestone, producing 301 kg. of CO^2, absorbs

$$301 \times 1,026 = 308,825 \text{ Cal.}$$

The proportion of the roasting heat thus absorbed is

$$\frac{308,825}{1,329,170} = 0.232 = \mathbf{23.2} \text{ per cent.} \quad (4)$$

(5) The 5-ton charge is moistened with 5 per cent of its weight of water, or 250 kgs., in order to keep down the temperature. This absorbs, simply in becoming vapor,

$$250 \times 606.5 = 151,625 \text{ Cal.},$$

Which, on the heat generated in the roasting operation, is

$$\frac{151,625}{1,329,170} = 0.114 = \mathbf{11.4} \text{ per cent.} \quad (5)$$

(6) If the gases pass away at an average temperature of 300°, and the air comes in at an average temperature of 15°, the gases cool off the pot to the extent of the difference between these two heat capacities:

Heat in the air entering:

$$3345 \text{ m}^3 \times [0.303 + 0.000027(15)] \times 15 = 15,225 \text{ Cal.}$$

Heat in gases escaping:

N^2	2609 m^3	$\times [0.303 + 0.000027(300)]$ =	861.1 Cal. per 1°.	
O^2	159 m^3			
SO^2	319 m^3	$\times [0.36 + 0.0003(300)]$ =	143.6	"
CO^2	313 m^3	$\times [0.37 + 0.00022(300)]$ =	136.5	"
H^2O	309 m^3	$\times [0.34 + 0.00015(300)]$ =	119.0	"
			1260.2	"

Total = 1260.2×300 = 378,060 Cal.

Proportion of the total roasting heat thus carried out:

$$\frac{362,835}{1,329,070} = 0.280 = \mathbf{28.0} \text{ per cent.} \qquad (6)$$

(7)

Heat Available.	*Calories.*
Sensible heat of air blast, at 15°	15,225
Combustion of charcoal	405,000
Net heat generated by the roasting	1,329,170
Total	1,749,395

Heat Distribution.

Sensible heat in the hot gases	378,060 = 22	per cent.
Decomposition of carbonates:		
Calcium carbonate	308,825 = 18	"
Iron carbonate	76,980 = 4	"
Evaporation of moisture	151,625 = 9	"
Sensible heat of product, at 400°	400,000 = 23	"
Loss by radiation and conduction	433,905 = 25	"
	1,749,395	

Reduction of Roasted Ore.

If the roasted ore is reduced in reverberatory furnaces, the chances are that the undecomposed sulphide it contains will react with the oxide or sulphate, forming metal and SO^2, and thus eliminating almost all of the sulphur left in the roasted ore; this results in the formation of no matte, or at most of very little rich matte. If the roasted ore is reduced in shaft furnaces, the carbonaceous fuel and strong reducing atmosphere of the same, tend to reduce oxides to metal and sulphates to sulphides before they reach the temperature at which they can react on sulphide, thus cutting out very largely the double reaction, and throwing into matte the larger part of the sulphur left in the roasted ore. This is highly advantageous if the ore has copper in it, even if only in small amount, as the matte will concentrate the copper in it, is easily separated from the metal and the slag, and forms a valuable by-product. Since most lead ores contain some copper, enough to make it pay to save it, the roasting of these is never pushed to completion, and the reduction in low shaft furnaces, run at moderate temperature, is pursued with the object of producing a copper-iron matte. Any arsenic or antimony left in the roasted ore is likely also to form *speiss*, a compound of arsenic and antimony with iron, copper, nickel, cobalt, lead and silver, which is heavier than matte, but lighter than lead, and separates out in the cooling pots between these. It is a highly undesirable product, because of its complexity and the difficulty of satisfactorily and cheaply separating its constituents; it is always to be advised to remove arsenic and antimony as completely as possible in the roasting operation, even at the expense of removing too much sulphur, and then to supply the sulphur needed in the smelting operation by mixing with the dead-roasted ore some raw sulphide ore free from arsenic and antimony, if such can be obtained.

In calculating the charge for such a smelting operation, the roasted ore must be charged with such amounts of iron ore and limestone as will, together with the gangue of the ore and the ash of the fuel used, make an easily fusible slag. To produce such a slag is of fundamental importance, since it must melt and become thinly liquid at the moderate temperature necessarily prevailing in a lead furnace. Experience has shown that a typical lead slag will contain about 30 per cent SiO^2, 40 per cent FeO and 20 per cent CaO, with 10 per cent allowed for other ingredients, such as Al^2O^3, etc., or in more general terms, that SiO^2, FeO and CaO are best present in the proportions 30:40:20. The other limitations are that a certain amount of hand-picked slag is always returned to the furnace for remelting and purification from matte, and that the fuel, coke, cannot melt more than a certain amount, say seven times it weight of inert material. With these conditions in mind, we will work out a typical smelting problem, the data for which are taken from Hofman's *Metallurgy of Lead*, page 311.

Problem 123.

A mixture of lead carbonate ore and galena (which represents pretty closely a partially roasted sulphide ore) is smelted with the addition of iron ore and limestone. The charges for the furnace consist of 1,000 pounds of burden (material to be smelted) and 150 pounds of coke (containing 10 per cent ash), and the 1,000 pounds consist of 100 pounds return slags and 900 pounds of lead ore, iron ore and limestone. The percentage composition of these materials is:

	Lead Ore.	*Iron Ore.*	*Limestone.*	*Ash of Coke.*
SiO^2	32.6	4.3	2.7	40.3
FeO	14.8	72.4	4.5	26.5
MnO	4.3	1.7	....	....
CaO	2.2	3.1	37.3	6.9
MgO	5.3	....	11.9	2.4
Al^2O^3	2.5	....	....	20.4
BaO	1.5			
ZnO	2.4			
S	4.4			
As	0.5			
Pb	20.7			
Cu	2.9			
Ag	0.17			

The iron present in these materials is really present mostly as Fe^2O^3 and only partly as FeO, but the analysis is expressed usually as FeO in order to facilitate the slag calculations. The analyses, as given, are not expected to add up to 100.

In making the calculations, assume that the slag to be produced contains SiO^2: FeO: CaO in the ratio 30:40:20; that the FeO here expressed includes the MnO, calculated to its FeO equivalent, and the CaO includes the MgO, BaO and ZnO calculated to their CaO equivalent. Assume also that all the ZnO of the charge goes into the slag, all the sulphur into matte, all the arsenic into speiss, of the formula Fe^5As, all the silver and lead into the lead bullion.

Requirements:

(1) The proportions of lead ore, iron ore and limestone to be used in the 900 pounds of these to a charge.
(2) The weight and composition of the slag formed.
(3) The weight and composition of matte formed.
(4) The weight and composition of speiss formed.
(5) The weight and composition of lead bullion formed.
(6) A balance sheet of the essential materials entering and leaving the furnace.

Solution:

(1) There are really only two unknown weights to be determined, for the sum of the three weights required is to be 900. Similarly, the ratio 30:40:20 really gives two conditions to be fulfilled, since there are practically two ratios to be worked to. The simplest method of solution is, undoubtedly, the algebraic one, letting x and y represent two of the ores, $900 - (x + y)$ the other, and then working out the weights of SiO^2, FeO and CaO in the slag, expressed in terms of x and y. The ratio 30:40:20 then gives us two independent equations, containing the two unknowns, and the problem is solved.

Let x = weight of lead ore.
y = weight of iron ore.
900 − x − y = weight of limestone.
15 = weight of ash of coke.
100 = weight of return slags.

Calculation of FeO Going into Slag.

Sulphur in 100 parts ore	4.4 lbs.
Copper in 100 parts ore	2.9 "
Sulphur united with Cu to form Cu^2S	0.7 "
Sulphur left over to form FeS	3.7 "
Iron needed to form FeS = $3.7 \times \frac{56}{32}$	= 6.5 "
FeO corresponding to this Fe = $6.5 \times \frac{72}{56}$	= 8.4 "
Arsenic in 100 parts of ore	0.5 "
Iron required to form Fe^5As = $0.5 \times \frac{280}{75}$	= 1.9 "
FeO corresponding to this Fe = $1.9 \times \frac{72}{56}$	= 2.4 "
Total FeO disappearing in matte and speiss	= 10.8 "
FeO left over to go into slag = 14.8 − 10.8	= 4.0 "

Therefore x parts of lead ore contributes to the slag.

SiO^2	0.326 x
FeO	0.040 x
MnO	0.043 x = 0.044 x FeO.
CaO	0.022 x
MgO	0.053 x = 0.074 x CaO.
Al^2O^3	0.025 x
BaO	0.015 x = 0.006 x CaO.
ZnO	0.024 x = 0.017 x CaO.

The FeO equivalent of MnO is 72/71 the MnO; the CaO equivalent of MgO is 56/40 the MgO, of BaO is 56/141 the BaO, of ZnO is 56/81 the ZnO. These ratios are the chemically equivalent values of these oxides, as taken from their molecular weights. Adding all these together, our lead ore contributes to the slag the equivalent of

SiO^2 0.326 **x**, FeO 0.084 **x**, CaO 0.119 x.

The y parts of iron ore similarly contributes to the slag:

SiO^2 0.043 **y**, FeO 0.741 y, CaO 0.031 y.

The 900 − x − y parts of limestone contributes likewise:

SiO^2	0.027(900 − x − y)
FeO	0.045(900 − x − y)
CaO	0.373(900 − x − y)
MgO	0.119(900 − x − y) = 0.167(900 − x − y) of CaO.

Therefore, total contribution of the limestone to the slag:

SiO^2 0.027(900 − x − y), FeO 0.045(900 − x − y), CaO 0.540(900 − x − y).

Contribution of ash of fuel to the slag, in similar manner:

SiO^2 6.1 FeO 4.0 CaO 1.6

Adding all these together, we have in the slag:

SiO^2	30.4 + 0.299 x + 0.016 y
FeO	44.5 + 0.039 x + 0.696 y
CaO	487.6 − 0.421 x − 0.509 y

According to assumption, these ingredients as thus summated should bear the relations 30 : 40 : 20. We therefore have

$$30.4 + 0.299\,x + 0.016\,y = \frac{30}{20}(487.6 - 0.421\,x - 0.509\,y)$$

$$44.5 + 0.039\,x + 0.696\,y = \frac{40}{20}(487.6 - 0.421\,x - 0.509\,y)$$

Whence x = lead ore = **523** lbs.
y = iron ore = **274** "
900 − x − y = limestone = **103** " (1)

(2) With the weights of materials used, as calculated, we can calculate the weights of the ingredients of the slag as:

	Lead Ore.	*Iron Ore.*	*Limestone.*	*Coke Ash.*	*Total.*
SiO^2	170.5	11.8	2.8	6.1	191.2
FeO	20.9	198.4	4.6	4.0	227.9
MnO	22.5	4.7	....	....	27.2
CaO	11.5	8.5	38.4	1.0	59.4
MgO	27.7	....	12.3	0.4	40.4
Al^2O^3	13.1	....	....	3.1	16.2
BaO	7.8	....	....	....	7.8
ZnO	12.6	....	....	....	12.6
					583.7

Percentage Composition and Check on Ratio.

SiO^2	32.8 per cent.	
FeO	39.0 "	
MnO	4.7 "	= 4.8 per cent. FeO.
CaO	10.2 "	
MgO	6.9 "	= 9.7 " CaO.
Al^2O^3	2.8 "	
BaO	1.3 "	= 0.5 " CaO.
ZnO	2.2 "	= 1.5 " CaO.

Summated SiO^2 : FeO : CaO
= 32.8 : 43.8 : 21.9 = 30 : 40 : 20

(3) Sulphur in 523 lbs. of lead ore = 23.0 lbs.
Copper in 523 lbs. of lead ore = 15.2 "
Sulphur to form Cu^2S with this Cu = 3.8 "
Sulphur to form FeS = 23.0 − 3.8 = 19.2 "
Fe to form FeS = $19.2 \times \frac{56}{32}$ = 33.6 "
Fes in matte = 19.2 + 33.6 = 52.8 "
Cu^2S in matte = 15.2 + 3.8 = 19.0 "
Total weight of matte = **71.8** " (3)

Composition of matte

Cu^2S	= 26.5 per cent.	= Cu	= **21** per cent.
FeS	= 73.5 "	Fe	= **47** "
		S	= **22** " (3)

(4) Arsenic in 523 lbs. of lead ore = 2.6 lbs.
Fe to form Fe^5As = $2.6 \times \frac{280}{75}$ = 9.7 "
Weight of speiss formed = **12.3** " (4)

Composition: Fe **79** per cent.
As **21** " (4)

(5) Lead in 523 lbs. of lead ore = 108.3 lbs.
Silver in 523 lbs. of lead ore = 0.9 "
109.2 " (5)

Composition: Pb **99.2** per cent.
Ag **0.8** " (5)

(6) Balance sheet of materials entering and leaving per 1,000 lbs. of burden:

Charges.		*Bullion.*	*Matte.*	*Speiss.*	*Slag.*	*Gases.*
Lead Ore 523						
SiO^2	170.5	....	....	....	170.5	....
FeO	77.4	....	Fe 33.6	Fe 9.7	FeO 20.9	O 13.2
MnO	22.5	....	....	....	22.5	....
CaO	11.5	....	....	....	11.5	....
MgO	27.7	....	....	....	27.7	....
Al^2O^3	13.1	....	....	....	13.1	....
BaO	7.8	....	....	....	7.8	....
ZnO	12.6	....	....	....	12.6	....
S	23.0	....	23.0	....	....	....
As	2.6	....	....	2.6	....	....
Pb	108.3	108.3	....	....	....	....
Cu	15.2	....	15.2	....	....	....
Ag	0.9	0.9	....	....	....	....

Iron Ore	**274**					
SiO^2	11.8	....	....	....	11.8	....
FeO	198.4	....	....	....	198.4	....
MnO	4.7	....	....	....	4.7	....
CaO	8.5	....	....	....	8.5	....
Limestone	**103**					
SiO^2	2.8	....	....	....	2.8	....
FeO	4.6	....	....	....	4.6	....
CaO	38.4	....	....	....	38.4	....
MgO	12.3	....	....	....	12.3	....
Ash of Fuel	**15**					
SiO^2	6.1	....	....	....	6.1	....
FeO	4.0	....	....	....	4.0	....
CaO	1.0	....	....	....	1.0	....
MgO	0.4	....	....	....	0.4	....
Al^2O^3	3.1	....	....	....	3.1	....
Return Slag	**100**	....	....	....	100.0	....
		109.2	71.8	12.3	683.7	13.2

THE ELECTROMETALLURGY OF LEAD.

As far as the present, the use of electrical methods in the metallurgy of lead has been confined to the Salom process of cathodic reduction of galena and the Betts process of refining crude lead bullion. Electrothermic methods of smelting, and even of roasting, are among future possibilities, as are also the leaching by suitable solvents and electrical precipitation of lead from the solutions, but they have not been commercially practiced.

The Salom process puts the powdered galena on a "hard-lead" plate, in a solution of dilute sulphuric acid, and using a "hard-lead" anode, passes a strong current through, reducing PbS *in situ* to Pb with formation of H^2S (with some hydrogen) at the cathode and oxygen at the anode. It was run commercially on a fair scale at Niagara Falls. For further details reference may be made to *Transactions* American Electrochemical Society, Vol. I., p. 87; II., p. 65; IV., p. 101.

The Betts process consists in using impure lead as anode in a solution of lead fluo-silicate, $PbF^2 . SiF^4$, strongly acid with HF. The refining plant and its operation are quite similar to a copper refining plant. The cathodes are sheet steel, greased, and the dense sheet lead deposited is stripped off from time to time.

Problem 124.

In a Salom apparatus powdered galena, density of powder 3.5. is placed in a layer 0.5 m.m. thick on a revolving lead table having an effective treatment area of 2.25 square meters. Current density 330 amps. per square meter of cathode surface. Time of treatment of the layer 90 minutes. Electrolyte dilute H^2SO^4. Resistance of cell 0.001 ohm. Heats of formation: (Pb, S) 20,300; (H^2, S) 4,800 (as gas); (H^2, O) 69,000. Assume reduction to Pb complete.

Required:

(1) The efficiency of application of the amperes passing to the reduction of the galena, and the percentage of ampere efficiency lost by the evolution of hydrogen.

(2) The average composition of the gases coming from the cell and their volume at normal pressure and 20° C., per hour. Assuming the electrolyte saturated with H^2S, H^2 and O^2 at starting.

(3) The working voltage absorbed, if the efficiency of reduction of galena were 100 per cent.

(4) The working voltage if the cell were kept running after all the galena was reduced.

(5) The average working voltage of the cell in actual operation and the distribution of this.

(6) The proportion of the power required by the cell which could be generated by burning the gases produced in a gas engine (if such were possible) at a thermo-mechanical efficiency of 100 per cent.

(1) Current used 2.25×330 = 742 amperes.

Lead theoretically reducible in 90 minutes

$0.00001035 \times 103.5 \times 60 \times 90 \times 742.5 = 4295$ grams.

Galena in the apparatus:

$2.25 \times 10{,}000 \times 0.05 \times 3.5 = 3938$ "

Lead under treatment:

$$3938 \times \frac{207}{239} = 3410 \text{ "}$$

Ampere efficiency of the treatment:

$$\frac{3410}{4295} = 0.794 = \mathbf{79.4} \text{ per cent.}$$

Per cent. of amperes evolving hydrogen = **20.6** " (1)

(2) If all the current evolved H^2S, the gases evolved would be:

$2H^2S$ O^2

2 parts 1 part.

If all the current evolved H^2, the gases would be:

$2H^2$ O^2

2 parts 1 part.

If 79.4 per cent. of the current evolves H^2S and 20.6 per cent. hydrogen, the average gases evolved will be:

H^2S	1.588 parts	= 52.93	per cent.
H^2	0.412 "	= 13.73	"
O^2	1.000 "	= **33.33**	" (2)

The volume evolved per hour is found as follows:

Oxygen produced by 1 ampere hour

$0.00001035 \times 8 \times 60 \times 60 = 0.29808$ grams.

Produced by 742.5 amperes, in one hour

$\times 742.5 = 221.3$ "

Volume at 760 m.m. and 0° C.

$221.3 \div 1.44 = 153.7$ litres.

Volume of gases produced per hour

$153.7 \times 3 = 461.$ "

$= 0.461$ cubic meter.

Volume at 20°

$$0.461 \times \frac{273 + 20}{273} = \mathbf{0.495} \text{ " (2)}$$

(3) Voltage for ohmic resistance

$0.001 \times 742 = 0.742$ volts.

Chemical work done if only H^2S is formed, per formula

$PbS + H^2O = H^2S + O + Pb$

$- 20{,}300 \quad - 69{,}000 \quad + 4{,}800 = - 84{,}500$ Cal.

Per chemical equivalent concerned $= - 42{,}250$ "

Voltage absorbed in chemical work

$42{,}250 \div 23{,}040 = 1.83$ volts.

Total voltage drop in the cell $1.83 + 0.74 = \mathbf{2.59}$ " (3)

(4) Chemical work done if only H^2 is liberated = 69,000 Cal.

Voltage absorbed in chemical work

$$\frac{69{,}000}{2} \div 23{,}040 = 1.49 \text{ volts.}$$

Total voltage drop in the cell = **2.23** " (4)

(5) Voltage absorbed in chemical work if 79.4 per cent. of the current evolves H^2S and 20.6 per cent. H^2:

$(1.83 \times 0.794) + (1.49 \times 0.206) = 1.76$ volts.

Total voltage drop, in average running = **2.50** " (5)

Logically, the 1.76 volts absorbed in chemical decomposition in average running is properly calculated thus, from the energy involved:

$$\frac{(42{,}250 \times 0.794) + (34{,}500 \times 0.206)}{23{,}040} = 1.76$$

(6) Heat of combustion of 1 cubic meter of the average gas:

H^2S	$0.5293\ m^3 \times 5{,}513$	= 2918	Cal.
H^2	$0.1373\ m^3 \times 2{,}614$	= 359	"
	Sum	= 3277	"

Calorific power of gas produced per hour:

$3277 \times 0.461 = 1511$ Calories.

Watt hours producible from this at 100 per cent. thermo-mechanical efficiency:

$$1511 \div 0.860 = 1757 \text{ watts.}$$

Current used by the cell, average running:

$$742.5 \times 2.50 = 1856 \text{ watts.}$$

Proportion theoretically regainable:

$$\frac{1757}{1856} = 0.95 = \mathbf{95} \text{ per cent.} \qquad (6)$$

The reason why more power is theoretically regainable than is used in doing chemical work in the cell, is that the gas engine burns the sulphur of the PbS ultimately to SO^2, and this is the source of great energy, while only a relatively small amount of energy was necessary to convert the PbS into H^2S ready for combustion.

Problem 125.

Lead bullion refined by the Betts process is 96.73 per cent lead, and the refined lead is practically pure. The anodes are 1.5 inches thick, and weigh, with lugs for suspension, 275 pounds. They are left in the tanks an average of nine days, running with 135 amps. per plate, whose active surface is 1,700 square inches. Space between anode and cathode 1 1/6 inches, specific resistance of solution 10 ohms. Each tank has twenty-two anodes and twenty-three cathodes, and produces an average of 545 pounds of lead per day. Power costs $50 per electric horsepower-year, as delivered to the tanks. Drop per tank, due to resistance of contacts, 0.15 volt; specific gravity of pure lead, 11.35.

Required:

(1) The weight of lead theoretically deposited by the current per day.

(2) The ampere efficiency of the deposition.

(3) The voltage drop per tank.

(4) The amount of anode scrap to be remelted in percent of the total anode weight.

(5) The average thickness of the cathode deposit per day.

(6) The power costs per ton of impure lead refined.

(1) Lead theoretically deposited by 1 ampere per day

$$0.00001035 \times 103.5 \times 60 \times 60 \times 24 = 92.55 \text{ grams.}$$

Per anode per day, dissolved

$$92.55 \times 135 \div 1000 = 12.5 \text{ kg.} = 27.5 \text{ lbs.}$$

Per tank, per day, deposited

$$27.5 \times 22 = \mathbf{605} \text{ "} \qquad (1)$$

(2) Efficiency of deposition

$$\frac{545}{605} = 0.90 = \mathbf{90} \text{ per cent.} \qquad (2)$$

(3) Amperes used per plate 135

Current density per square inch

$$= 135 \div 1700 = 0.0794 \text{ amperes.}$$

Current density per square centimeter

$$= 0.0794 \div 6.25 = 0.0127 \text{ "}$$

Distance of plates apart = 1.17 inches. = 2.93 c.m.

Resistance of 1 c.m. cube of electrolyte = 10 ohms.

Voltage drop in electrolyte

$$10 \times 2.93 \times 0.0127 = 0.37 \text{ volt.}$$

Voltage drop in connections = 0.15 "

Total voltage drop per tank = **0.52** " (3)

(4) Dissolved from anode in 9 days

$$545 \div 22 \times 9 = 223 \text{ lbs.}$$

Anode corroded in 9 days, assuming slime to fall off it

$$223 \div 0.9673 = 231 \text{ "}$$

Anode scrap = 275 − 231 = 44 "

Percentage of anode scrap $\frac{44}{275} = 0.16 = \mathbf{16}$ per cent. (4)

(5) Deposit of lead on one side of a cathode, per day

$$545 \div 44 = 12.4 \text{ lbs.} = 5.636 \text{ kg.}$$

Area of 1 side of a cathode = 850 sq. inches. = 5312 sq. c.m.

Deposit, per day, per sq. c.m.

$$5636 \div 5312 = 1.06 \text{ grams.}$$

Volume of this deposit $1.06 \div 11.35 = 0.093$ c.m.

Therefore thickness deposited per day = **0.93** m.m. (5)

(6) Bullion refined, per tank, per day

$$545 \div 0.0673 = 563 \text{ lbs.}$$

Power required per tank $2070 \times 0.52 = 1544$ watts. $= 2.06$ E. H. P.

Cost of power per year $= 50 \times 2.06 = 103.$ dollars.

per day $= 103 \div 365 = 0.28$ "

per ton of lead treated $0.28 \times \frac{2000}{563} = \mathbf{0.99}$ " (6)

Melting, Heating, Dissolving and Eluting.

By Oskar Nagel, Ph. D.

Melting Appliances.

Melting can be performed with direct firing, gas firing, or by means of hot water or steam, and also under pressure. As an example of direct firing, we give the description of a reverbatory melting and roasting furnace as used in the chemical industries.

As usually constructed, the hearth is built on one or two planes or steps, arched over with firebrick, upon which layers of ashes, sand, etc., are placed to prevent radiation of heat, the whole bound together with rails, securely tied with rods, both laterally and longitudinally. (Fig. 1.)

If two planes are provided in such a furnace the upper one is used for preheating, the lower one for melting the product.

A number of working doors are built into the sidewalls, through which the material is stirred and worked with hoes, paddles, etc. The material, in its passage through the furnace, travels toward or against the flame and is thus exposed to a gradually increasing temperature.

The doors are provided with rollers, which assist the operator in rabbling or working the material toward the discharging end, and are so placed that no two are opposite each other; this, in connection with the construction of the openings, renders all portions of the hearth readily accessible.

The advantage of the hand-stirred reverbatory furnace is that its first cost is small; the disadvantages are that heating is expensive, and the results obtained are irregular. Naturally the hot products of combustion can be further utilized for heating evaporating pans, etc.

The capacity of these hand-worked furnaces being not very large, it is, in many cases, necessary, especially for working large quantities, to use mechanically-driven melting or roasting furnaces, which, according to local conditions, and according to the cost of fuel, can be arranged either for coal-gas firing or producer-gas firing.

One of the best known types of these mechanically-driven furnaces is shown in Fig. 2. It consists of a horizontal cylinder of boiler iron, lined preferably with firebrick, the cylinder resting on friction rollers and revolving between a fire-box and a flue. The flame from the fire-box passes directly through the cylinder, and thence, mixed with the gases that are eventually generated by the heated material, into a dust chamber (if the latter is necessary) and to the stack. The cylinder is provided with manholes for receiving and discharging the material.

The cylinders are made to revolve slowly, the smaller ones by applying power to a shaft carrying the friction rollers, the large ones by a pinion which engages a spur gear surrounding the cylinder. The fire-box is made either movable or sta-

tionary. In the former case it is constructed in the form of a car running on a track, usually placed at right angle to the axis of the cylinder and having a short flue on one side that comes exactly opposite the throat of the furnace. In this way the fire-box can be run in front of a cylinder containing a fresh charge and fired until the charge is melted down, or (in case of a roasting furnace) until the sulphur is thoroughly ignited and then run opposite another cylinder.

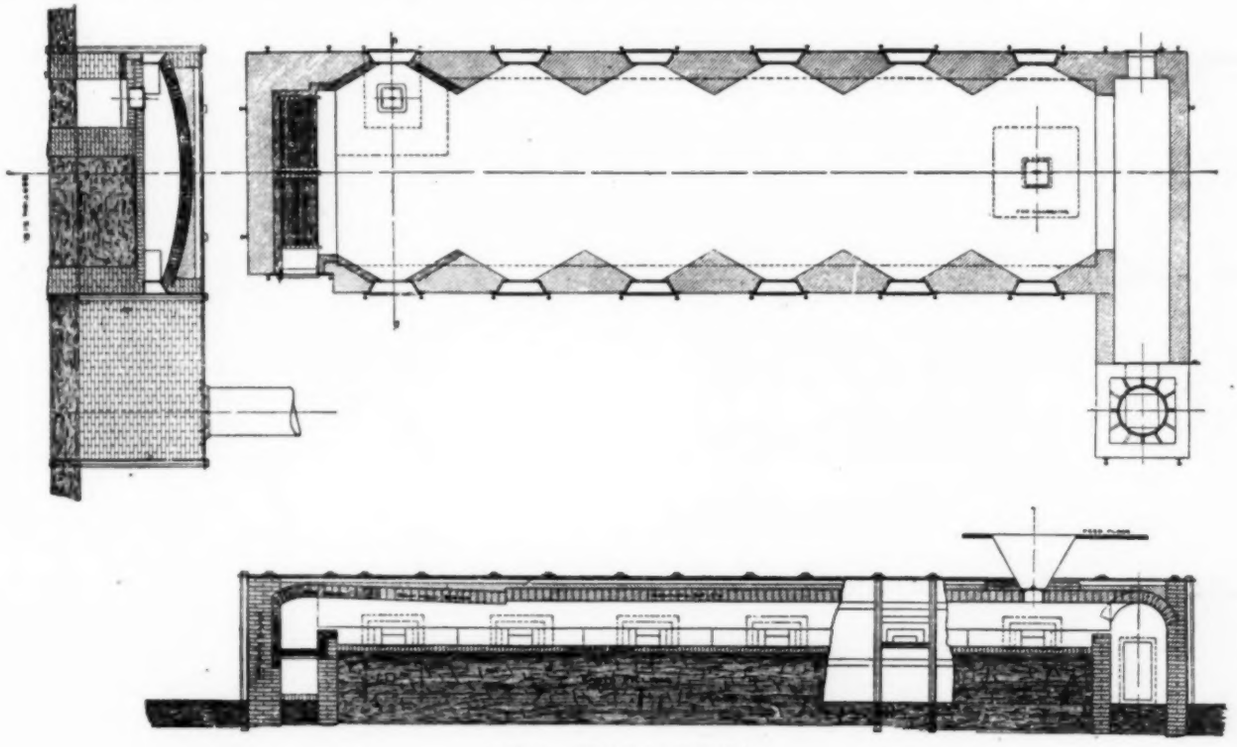


FIG. 1.—MELTING FURNACE.

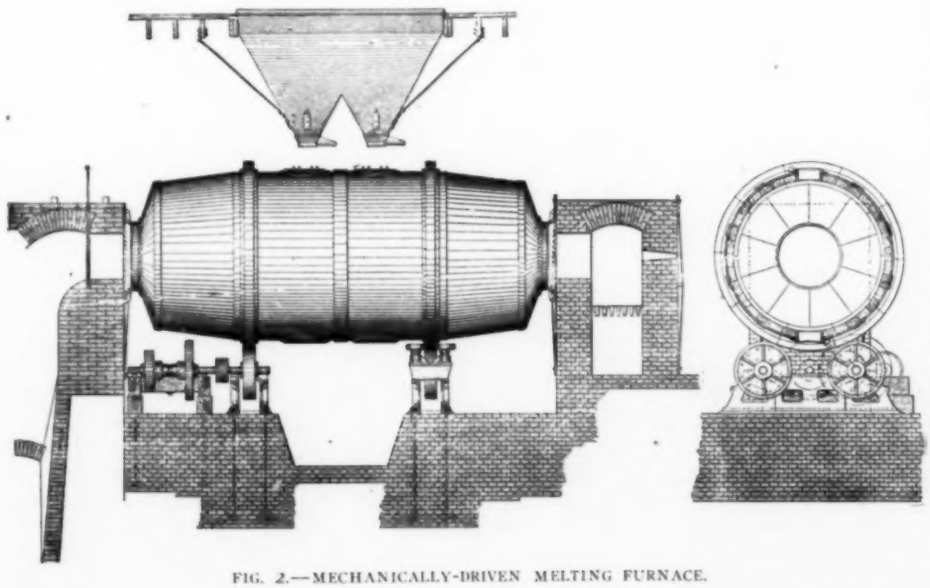


FIG. 2.—MECHANICALLY-DRIVEN MELTING FURNACE.

If it is desired to use producer-gas firing instead of coal firing, a gas producer in place of the fire-box is connected with the furnace.

There are also in use melting and roasting furnaces built similar to Fig. 1, but provided with mechanical stirrers.

Furnaces of this kind are built by the Allis-Chalmers Co., Milwaukee, Wis.; F. M. Davis Iron Works Co., Denver, Col., and Chisholm, Matthew & Co., Colorado Springs. Col. Details of special roasting furnaces (as distinguished from smelting furnaces which are also used for roasting) will be given in a later article.

If the products to be melted are heated by means of steam, hot water, etc., the apparatus are so arranged that the products do not come in contact with the steam, and that the transmission of heat takes place as in steam boilers through the walls of the vessel.

This is done (as will be described later in detail) by using a double wall and filling the space between these two walls with steam or any other heat carrier, or by arranging steam coils inside the vessel.

The latter construction is, as far as the economy of heat is concerned, to be preferred to the former; but the attendance of this apparatus is more inconvenient, as the coils are frequently interfering with the complete removal of the charge.

These apparatus are made in various shapes, cylindrical, conical, egg-shape, etc. If liquids are to be heated to a temperature above their boiling point, *i. e.*, if the work is carried out under pressure, especially constructed apparatus are used, which are called digesters. (Fig. 4.) Digesters, like many apparatus used in chemical engineering, are generally built to order, according to the designs of the chemical engineer of the firm which places the order.

These are cylindrical or spherical vessels, which are, corresponding to the pressure generated, of heavy construction and generally provided with a removable cover on top, which al-

lows the cleaning and inspection of the interior space of the apparatus.

The digesters are further provided with charging openings, safety valve, thermometer tube and manometer and are heated by means of steam or direct fire. The latter heats either the walls direct, or if a double wall is used, the heat-transmitting substance, water, oil or alloys.

It is frequently necessary to use digesters, which are provided with stirrers.

As regards the materials to be used in the construction of digesters, it is obvious that they have to be selected according to the properties of the substance to be treated in the ap-

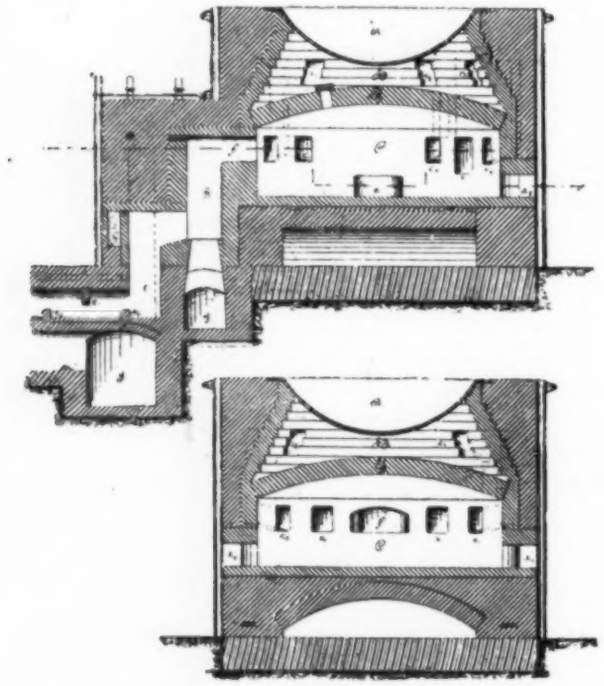


FIG. 3.—SIEMENS CALCINING AND EVAPORATING FURNACE.

paratus; digesters made of cast iron are most frequently used; if necessary they are lined with lead or provided with an enameled lining. Wrought iron and copper are only rarely used.

These apparatus, which are built in various sizes, require, on account of the danger of the operation, special care in the making. Hence a special brand of cast iron is used for preparing these castings; the bolts are made out of rivet steel. Before being used these apparatus are being tested at a pressure of 100-200 atmos., depending on the pressure which they will have to stand in the regular operation.

The glowing of products is generally carried out in similar furnaces as the melting and is called calcination in the chemical industries.

Calcination is used for removing certain substances, for instance, water, from a material by means of heating. The furnace shown in Fig. 1 and also shaft furnaces are used for this purpose. Sometimes cast-iron retorts are used for calcining.

A very durable and very economical construction of a calcining and evaporating furnace is shown in Fig. 3. (Designed by Friedrich Siemens, in Dresden.) In this furnace the radiant heat of the active flame comes into effect only in the calcining space below the evaporating kettle. The neutral products of combustion are also taken off from this space C, so that the evaporating pan A is heated only by local circulation of the firing, which is effected by connecting channels c_1, c_2, c_3 provided between the calcining hearth and the pan in the space H.

The heat of the products of combustion leaving the calcining space is utilized for preheating the combustion air, whereby the temperature of the heating flame and its capacity for heat radiation are increased.

The heating of an evaporating pan, effected by local circulation of the fire-gases, insures the greatest uniformity in heating, long life of the pan, no warping of the material (cast iron), great capacity and low fuel consumption. It also prevents the formation of crusts.

Solid, liquid or gaseous fuel can be used in this furnace; in the furnace shown in the illustration gas firing is used, which is very suitable in most cases.

The gaseous fuel goes through flue g to the furnace, is mixed with the air (coming through flue l) in chamber R, travels as flame through flue f into the calcining space and is finally escaping through the chimney. The exchange of heat between the calcining space C and the evaporating pan A is effected by the channels c_1, c_2, c_3 already mentioned; for increasing the heat of the pan, if required, there are also provided openings in arch G, which can be closed or opened (for decreasing and increasing, respectively, the heat). The openings of the channels c_1, c_2, c_3 can also be regulated by means of firebricks. The material to be calcined is transported from

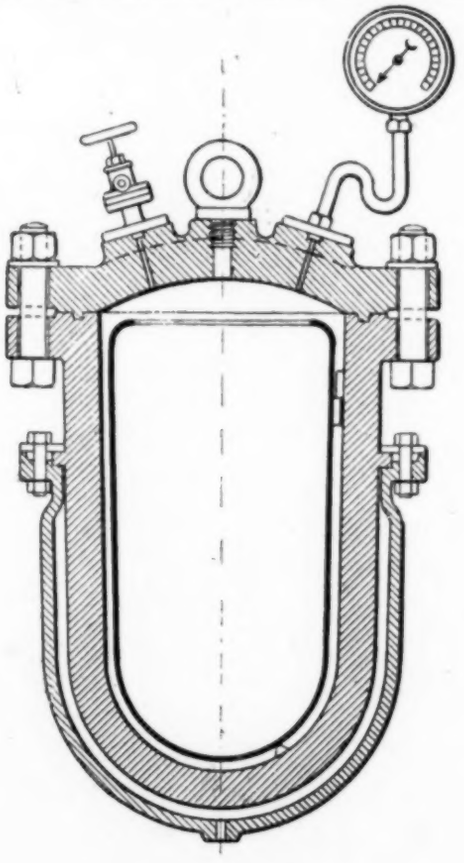


FIG. 4.—DIGESTER.

the pan to the calcining space by means of inclined planes in the brickwork; it is distributed and worked through the working doors a_1, a_2.

Dissolving and Eluting Appliances.

The new product obtained by melting sometimes consists of several substances of various composition, and thence it is necessary to treat these molten masses further for separating their components. This treatment depends entirely upon the property of the molten mass; if the latter is perfectly soluble, it is treated with a liquid until it is completely dissolved, and then the individual components of the solution so obtained are separated by various methods.

If the molten mass is only partly soluble a solution is also made in a suitable solvent and the solution obtained is separated from the insoluble solid components by operations, such as filtering, etc.

According to the solubility of the mass, various methods are used for effecting a complete recovery of the soluble components.

Wherever water of ordinary temperature can be used, this naturally will be done, but in cases where cold water is not effective, hot water or steam has to be employed. This operation can be performed in open or closed vessels, and the decision in this selection will depend on the fact whether high

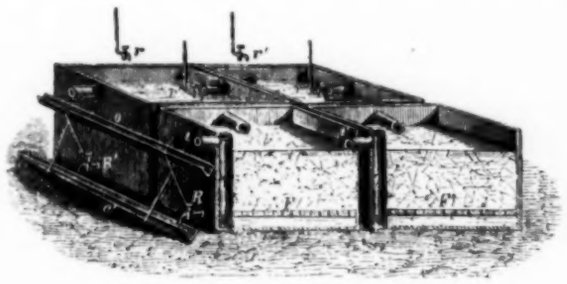


FIG. 5.—SHANKS APPARATUS.

steam pressure is required, and, if during the solution, detrimental vapors are generated.

In many cases, in place of water, a dilute solution of the substance to be recovered will be used, as thereby the same is gradually concentrated, which means a considerable saving of coal in the evaporation, eventually to be performed for final concentration.

For increasing the velocity of the dissolving process and for obtaining solution nearer to the point of saturation in open and closed vessels, stirrers are used similar to those used in mixing machines.

Vertical stirrers are to be preferred to horizontal ones, as in the latter the stuffing boxes of the shaft are exposed to a considerable wear, partly because they are always in the solution, coming continuously in frictional contact with the solid particles contained in same, and partly as the entire pressure of the stirrer against the mass, and the weight of the stirrer has to be absorbed and carried by them. A further disadvantage of the horizontal construction is the more expensive cost of repairs.

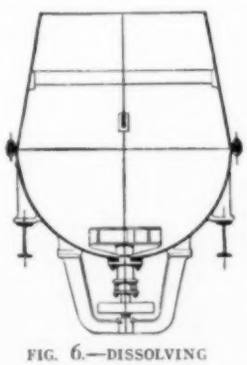


FIG. 6.—DISSOLVING APPARATUS.

In vertical stirrers only one stuffing box is required, which is provided on the top, and which, in closed vessels, has to be only steam tight, as the solution does not come up so far.

The residuum obtained by the separation of the unsoluble solid substances from the liquid (by simple filtering, centrifugals, etc.) contains generally so many liquid particles still enclosed that the recovery of same is of advantage, and in some cases even absolutely necessary.

Hence in filter-presses the residuum is washed by means of water, diluted solutions of the respective liquid or by other liquids, either until the residuum is of the purity required or as long as the wash-waters obtained allow an economical using over of same.

Similar conditions prevail with material obtained by centrifugals.

As will be described in another article, special arrangements are made on filter-presses for eluting purposes.

If only the solid components are to be recovered, the wash-waters obtained in the various stages are not separated; however, they are separated according to the specific gravity, if the solutions are to be worked up. This is done most conveniently by connecting the outlets of the respective filtering apparatus with a main pipe line, and by leading the liquids therefrom according to their specific gravity through various pipe lines to the storage vessels. The liquids of sufficient strength can now be worked up directly and the thinner liquids can be used as eluting liquor for enrichment.

The proper selection of the eluting or washing arrangement, and the limit to which these operations are carried on, is frequently one of great importance for economy.

The materials used in the construction of these apparatus depend upon the properties of the solution; the construction and operation of these apparatus, again, depend upon the materials.

A dissolving and eluting apparatus, which is widely used in the inorganic industries, is the apparatus of Shanks, which is based upon the fact that the specific gravity of a solution increases with its concentration, and that a column of a weak solution is kept in equilibrium by a lower column of a stronger solution. The tanks are arranged on the same level; water, passing through the tanks is dissolving or eluting the material and is getting constantly more and more concentrated. The column of the liquid is decreasing from tank to tank, from the first, which contains pure water, to the last, from which the concentrated solution is running off. The tanks are provided with a false bottom F (Fig. 5), made of perforated sheet iron. A pipe T open at both ends, and having a diagonal section at the bottom is reaching from the bottom of each tank to the surface. Each pipe T is provided at the top with a short pipe t, connecting one tank with the other. By means of the water pipes r each tank can be filled with water. The solution is discharged through cocks R. For crude soda ash, four washings are generally sufficient.

An apparatus for dissolving materials without the use of direct steam (Fig. 6) is built by Werner & Pfleiderer, Saginaw, West Side, Mich. In this apparatus the material to be treated is drawn with the liquid by means of a tangential wheel into the interior of the same, and is thrown out sidewise with great force. As the material passes through the interior of the tangential wheel, up the wall of the egg-shaped trough, and in the axis of the trough to the tangential wheel, there are many changes of motion which result in an energetic treatment of the material.

Heat-Insulating Materials.

In *Stahl und Eisen*, of Nov. 20, Dr. STEGER discusses the important problem of providing a good heat insulation for metallurgical furnaces and apparatus.

The simplest heat insulator is non-circulating atmospheric air. But the method of enclosing an apparatus within a double jacket, with a sufficient space of air between the walls, is not always applicable. As a substitute it is possible to use porous bodies, brick containing numerous holes and pores filled with air.

The manufacture of porous brick from kieselgur (infusorial earth) has long been known. The kieselgur, mixed with a binding material like clay or water glass, is formed into brick and burnt. Care must be taken in burning, since too much heat causes sintering and the heat-insulating property is lost. A properly treated brick of 250 mm. (9⅞ inches) length may be heated to red heat at one end, while the other end is heated so moderately only that it is possible to touch it with the hand.

Since kieselgur is not everywhere available at a sufficiently low price, heat-insulating brick has been made from other materials which are *per se* better conductors of heat, but which are provided artificially with numerous pores. For this purpose, for instance, an intimate mixture of clay and finely divided organic substances is used. The latter burn, when the

brick is heated, under the action of the atmospheric air which enters into the mass through the many cracks which form. There are thus produced innumerable pores within the mass. Suitable materials to be added to the clay are finely divided peat, bituminous coal, sawdust, straw, wool waste, tar, etc. They are added to the clay mud as a very fine powder, and the mass is very thoroughly stirred and mixed to make sure that the pores are uniformly distributed throughout the mass. The clay must be "fat," so as to be able to absorb a large quantity (up to 75 per cent) of organic additions. These additions contribute to the thorough burning of the clay and thus reduce the amount of fuel required.

If such brick is to be used for refractory linings at very high temperatures, not only a good refractory clay, but such additions should be chosen which contain very little ash. The purest brick is obtained from such clay masses, to which is added a substance which evaporates completely, like naphthalene, resin, tar or ammonium carbonate. But these materials are expensive and means should be provided to recuperate them; for this purpose the brick, before being burnt, should first be moderately heated in a muffle furnace so that the evaporating materials distill off and are recovered.

"Under certain conditions it may be advantageous to burn out the added organic substance not entirely, but only partly, so as to gain not only porosity, but also strength. The zinc companies[1] in Western Germany add throughout ground coke to their retort mass. This addition amounts to only 10 per cent, but gives a very dark color to the mass. The retorts when pressed receive a glaze cover which melts in the furnace fire and prevents the burning of the coke particles. Bischof (Die feuerfesten Tone, 1895, page 206) says concerning this addition of coke to clay: 'If a clay contains considerable carbon, the carbon which is present or which is absorbed from the fire gases, as long as it is not burned out, prevents the clay from melting. Any slag or clayey mixture may be made more refractory for a certain time in this way by an addition of carbon.' The same author says (p. 292): 'Anthracite, then coke, and still more charcoal are much more liable to be inflamed and burn off than graphite, but as long as they are enclosed within clay and do not burn out, they make the clay more refractory and less liable to crack. These quotations confirm the experience that from clayey masses, to which coke, anthracite or other kind of coal is added, bodies can be obtained by careful burning, the oxidizable constituents of which are only partly removed and which are therefore at the same time porous and stand higher temperatures and are less liable to crack than the clayey mass alone."

Brick which is dense on one surface, but otherwise porous, is made by pressing a thin layer of clay and chamotte, then putting on it clay of the same quality and the same content of water, but mixed with an oxidizable material, for instance, sawdust, pressing again, drying and burning. The sawdust burns out. Such brick is an excellent insulator for metallurgical furnaces.

The highest degree of porosity in brick can be obtained by combining the methods, *i. e.*, by mixing kieselgur and organic substances with very small quantities of binding materials like clay or water glass. During the burning the inserted organic substance prevents the mass from sintering together and becoming dense and compact. After the organic substances are burned out it becomes necessary to take care in maintaining the proper temperature. The finished brick has both the pores due to the burned-out organic substances and the natural pores of the kieselgur. Of special advantage is the addition of very finely powdered cork with kieselgur. Cork contains innumerable pores, even in the smallest particles. If it is desired to have in the product regular channels running in certain directions, then thin wooden rods or threads are placed in proper distances from each other, which later burn out.

Very suitable as a heat-insulating brick, for instance, for roof construction, are hollow blocks. Thus Hourdis brick, which is much used in Southern Europe as an insulating brick, is 25 cm. (9⅞ inches) broad, 6 to 10 cm. (2⅜ to 4 inches) high, and 50 to 100 cm. (1 foot 8 inches to 3 feet 3 inches) long, but the thickness of the walls is only 7 mm. (a little more than ¼ inch). Thin partitions pass through the hollow spaces so that a number of channels of square cross-section are formed.

This brick is made from clay which contains a certain amount of magnesia, about 5 per cent, and 7 to 8 per cent of iron oxide and 12 per cent lime. Although this brick is made from a clay, which is not really refractory, it stands temperatures up to 1,000° C.

For higher temperatures it becomes necessary to use good special clay for making the brick, and it is advisable to make the thin walls of these hollow blocks porous in the manner described before. To increase the strength of the blocks they may be made dense and non-porous on the outside.

By putting together a series of hollow blocks, channels can be made for special purposes; for instance, for getting pure, hot dry air.

The use of hollow and porous brick of light weight reduces the cost of erecting light structures. This brick is also useful for damping sound.

[1] It should be emphasized that in the case of retorts for zinc distillation the object is not to get a good heat insulator, but just the opposite, to get a good heat conductor, since the heat is to be transferred from the outside to the inside of the retort. The ideal material for a zinc retort should be highly refractory and resistant to the chemical attack to which it is subjected, and, at the same time, a very good conductor of heat.—Ed.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Production of Power From Peat.

The inaugural address, delivered by the chairman of the Dublin local Section of the Institution of Electrical Engineers, dealt with a scheme of utilization which makes 60 per cent of the total heat derived from the peat available for the necessary drying; and this, from an engineering point of view, makes it possible, when the value of the ammonium sulphate obtained covers the cost of preliminary operations.

If 85 pounds of ammonium sulphate be obtained from 1 ton of dry peat, 1 ton would be yielded by 26½ tons, the respective values being £12 (less value of sulphuric acid), and 7s. and 11d.,—say, 7s.—or 3s per ton of peat containing 40 per cent of moisture, which is approximately the amount in air-dried peat.

A means is sought of obtaining peat equal to the air-dried at 3s. per ton. In Ireland air-dried peat cannot be produced for this sum.

There are various devices. The Bromsowsky machine is said to yield 2 tons of peat "cut and laid to dry" per man per day; labor thus costing 1s. 6d. per ton. This is a hand-worked machine. The Anrep, a Swedish machine, is more elaborate and deals with twelve times as much, at a cost of 3s. 4d. per ton of dry peat; but the power absorbed is excessive. The Schlickeysen, or Dolberg, machine was also mentioned. The first of these machines gathers peat containing a natural quantity of moisture, according to the season, working best, of course, in normal summer and early autumn. The second macerates and forms the peat in briquettes containing 80 per cent of moisture. The last also macerates and presses and delivers the peat with 50 to 60 per cent of moisture, but appears to be encumbered with undesirable complications; yet it has good points which more than compensate.

The question of utilization of waste heat sufficiently to expel the residual moisture was then gone into. From 100 pounds of dry peat 864,400 B. T. U. are evolved; 648,000 in the

gases. If these gases were employed in a gas engine of 30 per cent thermal efficiency, 454,000 units are lost and absorbed in the exhaust and the cooling water, leaving 194,000 units available for power.

Can this be realized? The data appear to indicate that the efficiency is 45 per cent; and "practical efficiency" is said to be 30 per cent.

The address also dealt with the heat necessary to raise steam for the producer and that required to concentrate the ammonium sulphate, and concluded by drawing attention to difficulties which have arisen through past failures.

THE DAVY CENTENARY OF THE FARADAY SOCIETY.

There was a good attendance at the ordinary meeting of the Faraday Society, which was held at the Institution of Electrical Engineers on Tuesday, Dec. 17, 1907, when Dr. F. G. Donnan read a very interesting paper by J. T. Barker, B. Sc., illustrated by lantern slides, on "A Physico-chemical Study of the Complex Copper-Glycocoll Sulphates," which, although mainly of interest from a chemical point of view, yet opened up a new vista of the correlation of the forces.

Dr. F. Mollwo Perkin then read a most valuable paper on the discovery of the alkali metals by Humphrey Davy and its bearing on industry.

The Davys originally came from Norfolk, but settled later in Cornwall, where Edmund Davy, the grandfather of Humphrey, was a builder, and his son was named Robert, who, apparently thriftless, died, leaving his affairs in a complicated state when Humphrey was only 16. He at once realized his family duties, studied hard, and very soon was apprenticed to an apothecary and surgeon at Penzance. In 1797 he began to study natural philosophy and chemistry. Little is known of this early work. It was meeting Gregory Watt, son of James Watt, that decided Davy to devote himself to science.

In 1798, Dr. Beddoes, who had been trained as a doctor of medicine, fitted up sanatoria at Bristol, and asked Davy to take charge of his "Pneumatic Institution." Davy studied the action of gases in various ailments and gained experience with nitrogen monoxide, with which he was nearly overcome. Maria Edgeworth, a sister of Dr. Beddoes, tried this gas; and her sensations are a revelation. Davy continued experimenting until, in October, 1800, a letter to Dr. Gilbert states that he found galvanic action purely chemical, and describes the action of water and acids on zinc as well as the facts connected with polarization and recovery. On Feb. 16, 1801, he was elected to responsible positions at the Royal Institution, and his first lecture was on galvanic phenomena. His appearance was not what is termed prepossessing. Rumford said he must first lecture in a small room to rehearse, but on hearing him gave him *carte blanche*. Davy then worked on agriculture.

In October, 1807, he began to study voltaic electricity and its action on alkali compounds, and it is apparent that he seems not to have experimented very much in this way before the Autumn of 1807. His Bakerian lecture astonished his hearers by its lucid description and practical production of potassium and sodium. His first attempts were made on aqueous solutions of the hydroxides with large batteries of copper-zinc couples, using an electrolyte of nitrite acid and "alum." He recognized the fact that the presence of water interfered with the reduction, and then tried fused potassium hydroxide with 100 cells of 6-inch highly charged plates in various experiments, and obtained, what he termed, the inflammable principles of potassium and sodium.

By further research on pure materials he obtained some most remarkable results, which are fully described in the paper; and these led him to work on alkaline earths, from which he obtained amalgams by use of mercuric oxide, which he distilled, using suitable precautions against oxidation, but he seems to have had doubts as to the purity of the products.

Students of pure science can, with difficulty, appreciate the grand results this man obtained, working under great difficulties with crude apparatus, by his own persistent efforts. He had recognition in his day; he loved applause, and had it, and his labors constitute the basis of much that modern science can demonstrate. The paper then went on to describe the progress of commercial production of the alkali metals, giving outlines of the several processes employed since 1827, and deals at some length with their chemical aspect, concluding with Darling's method (which is not in commercial use now).

MARKET PRICES, DECEMBER, 1907.

Tin opened at £133 per ton, reached £134.10 on the 6th, after falling to £125.10 on the 11th it rallied to £127.5 on the 12th, and fell to £116 on the 17th, after which it rose to £122 on the 23d, and after a slight fall during the holidays closed at £123.10.

English lead opened at £16.5, falling almost continuously until the 16th, when it reached about £13.10; it rose steadily until the 24th, reaching £15.5; the price on the 31st was £14.10.

Scotch pig iron opened at 60s. per ton and fell to 59s. 6d. on the third, at which it remained until the 10th. The 11th saw a further drop to 59s., remaining until the 13th at 59s. It dropped again to 58s. on the 16th, remaining at this figure until the 27th, and closing at 57s. 6d.

Hematite pig iron opened at 67s. 10d. per ton, fell to 67s. on the 3d, remained until the 5th, and touched 68s. 9d. on the 12th, falling to 66s. 2d. on the 16th, it fell very slowly until the 31st, when 65s. 10d. was reached.

Cleveland pig iron opened at 49s. 10d., and varied from 49s. to 50s. until the 30th, when it fell to 48s. 6d.

Copper opened at about £62 per ton, and varying slightly until the 6th fell to £58.15 on the 12th, the price was £59.5 on the 13th, and after falling to £57.5 on the 17th rose to £60.10 on the 23d and closed at £62.

Other closing prices: antimony was £24 to £35 per ton; ammonia sulphate, £12.10 per ton; copper sulphate, £22 per ton; bleaching powder, 35 per cent. £4.10 per ton; white caustic soda, 77 per cent, £11.2.6 per ton; shellac, £6.5 per cwt.

Coal tar products: benzole, 90 per cent, 7d. per gallon; carbolic acid, liquid, 97 per cent to 99 per cent, 1s. 1d. per gallon; creosote, ordinary good liquid, 2s. 5½d. per gallon; naphtha solvent, 90 per cent at 160° C., 11d. per gallon. Pitch, £1.1.6 per ton.

Imports of Ferro Alloys.

The statistics of the American and Foreign Iron Trades for 1906, which has just been issued by the American Iron and Steel Association, gives the following figures as to the imports of spiegeleisen, ferro-manganese and ferro-silicon in 1904, 1905 and 1906:

ARTICLES.	1904.		1905.		1906.	
Gross Tons.	Tons.	Values.	Tons.	Values.	Tons.	Values.
Ferro-manganese	21,814	$707,037	52,841	$1,844,651	84,359	$4,953,644
Spiegeleisen	4,623	132,461	55,457	1,336,104	103,267	2,942,940
Ferro-silicon	3,691	184,229	11,044	558,906	11,863	788,085
Total	30,128	$1,023,727	119,342	$3,779,661	199,489	$8,684,669

With respect to ferro-silicon, it is clear from the values given that the bulk of the imports was low-grade ferro-silicon.

In this connection it may be interesting to note that the price on high-grade ferro-silicon has recently also gone down to a considerable extent. While the high price last year was $104 for 50 per cent ferro-silicon, it is now offered for $85, while 75-per cent ferro-silicon is reported to be offered for $127.50. In other words, the buyer pays exactly according to the silicon content alone.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Silicon Monoxide.—H. N. Potter, 875,675, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon monoxide is made according to the equation $SiO_2 + Si = 2SiO$, so that the whole reacting mass is converted into monoxide. There is no CO gas liberated, and the absence of carbon renders it impossible to produce silicon carbide which the inventor has sometimes found in small quantities as an impurity in silicon monoxide powder. Silicon carbide is a particularly undesirable impurity, as it cannot be removed by the action of any reagent which does not attack silicon monoxide, whereas, many other impurities, such as magnesia, alumina and calcium oxide can be largely removed and iron to a somewhat lesser degree. The reaction is carried out in an electric vacuum furnace with a mixture of 28 parts of granular silicon and 60 parts of granular silica. If it is desired to avoid the presence of silicon dioxide in the product a charge having a slight excess of silicon may be used.

Silicon Monoxide Powder.—H. N. Potter, 875,676, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

In making silicon monoxide the main portion is obtained in the form of a finely-divided powder, while a small portion appears in vitreous form. The powder is more useful and the vitreous monoxide may be reduced to a finely-divided powder by breaking it into granular form and charging it into an electric vacuum furnace, where it does not melt but appears to be sublimed or volatilized and driven away from the high temperature locus, cooling and settling in a finely-divided state. The vitreous monoxide, which is a by-product of silicon manufacture, may thus be used as a raw material for making the useful silicon monoxide powder.

Silicon Monoxide.—H. N. Potter, 875,286, Dec. 31, 1907. Application filed June 14, 1905. Assigned to George Westinghouse.

When silicon is highly heated in air under reduced pressure, or in an atmosphere poor in oxygen, silicon monoxide is produced. When the silicon thus heated is in a vaporous form the resulting product appears in the form of silicon monoxide powder. The crystalline metallic silicon may be piled about the graphite core resistor in a vacuum furnace, and thus heated, or the silicon may be used directly as resistor.

Silicon.—H. N. Potter, 875,285, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon is produced by the reaction $SiO + C = Si + CO$. Silicon monoxide powder and finely subdivided carbon are mixed and heated in an electric furnace in the absence of free oxygen or other reactive gas.

Production of Silicon.—Henry Noel Potter, 875,672, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon is produced by the reaction $SiO + SiC = 2\ Si + CO$. Silicon monoxide and silicon carbide are mixed in finely subdivided form and heated in an electric furnace in the absence of free oxygen or other reactive gases.

Silicon Carbide.—Henry Noel Potter, 875,673, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon carbide is produced by the reaction $SiO + 2\ C = SiC + CO$. Finely subdivided silicon monoxide and carbon are mixed and heated in an electric furnace in the absence of free oxygen or other reactive gases.

Silicon Dioxide Powder.—Henry Noel Potter, 875,674, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon dioxide in a state of extreme comminution is produced by first making silicon monoxide and then oxidizing it according to the equation $SiO + O = SiO_2$. For instance, air may be blown through an electric furnace in which silicon monoxide is being produced, or silicon monoxide powder and air are blown through a highly heated tube or through an oxidizing flame.

Silicides.—E. F. Price, 873,328, Dec. 10, 1907. Application filed Nov. 14, 1905.

The sides 1 of the furnace shown in Fig. 1 are made of carborundum, siloxicon or silica, or of carbon, while the hearth 2 is made of carbon, the sides and hearth being surrounded by a metal casing 3 with a terminal 3', the carbon hearth constituting one electrode. The other electrode is the carbon rod 4. The tap holes 5 and 6 are for slag and metal respectively. An arc is established between the end of the electrode 4 and the hearth 2. The charge, consisting of finely ground silica and coke (both in relatively large proportion) and iron ore, is then gradually fed into the furnace until it is in normal working condition, when the depending electrode is embedded, as shown in the illustration. As the reduction proceeds the molten ferro-silicon collects at the bottom of the furnace and is run out through 6. The use of a charge containing a large percentage of silica makes it possible to produce silicides containing 50 per cent and upwards of silicon. Such a charge is also substantially a non-conductor of electricity, so that the working chamber of the furnace can be filled without shunting the current from the electrodes through the charge. The excess of carbon in the charge facilitates the reductions and protects the electrodes, and the continuous mode of operation enables the efficiency of the furnace to be maintained at a high figure. Metallic iron may be substituted for iron ore in the charge.

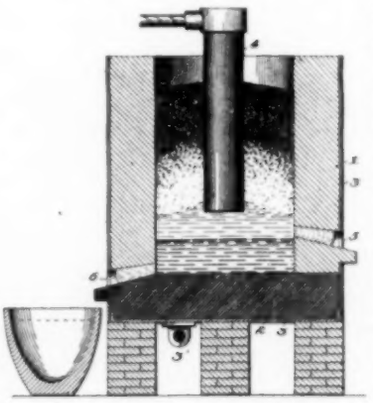


FIG. 1.—FERRO-SILICON FURNACE.

Ferro-Vanadium.—E. F. Price, 875,208, Dec. 31, 1907. Application filed Dec. 29, 1906.

Low-silicon ferro-vanadium is produced from a silicious vanadium sulphide ore in continuous operation by the following stages. The vanadium sulphide, after having been roasted and changed into vanadium oxide, is mixed with iron or iron oxide and with carbon, the latter being employed in the minimum proportion required to effect reduction. A basic flux, such as lime, is added. The mixture is then charged into the electric furnace, the electrodes of which are embedded in the charge. The furnace is provided with a carbon lining, at least at the zone of contact with the slag, and with tap-holes for the slag and alloy. Reduction is then effected and continuously maintained by passing an electric current through the charge, the zone of reduction being surrounded by a considerable body of the charge to retain the heat and protect the oxidizable electrodes and metallic product from the action of the air. The products are tapped off and the charge mixture

added as required, the slag or alloy being separated either within or outside of the furnace. The high-silicon ferro-vanadium is then treated with a suitable reagent to oxidize and remove the contained iron, preferably with an oxide of either iron or vanadium so as to introduce no metallic impurities.

Calcium Carbide Furnace.—J. C. King, 872,351 and 872,352, Dec. 3, 1907. Application filed Jan. 5, 1904. Assigned to Willson Carbide Works Co. of St. Catharines, Ltd.

The object is to produce pure carbide without crust, since the latter is practically a waste product. The construction of the furnace is shown in Fig. 2. A is a carbon pencil con-

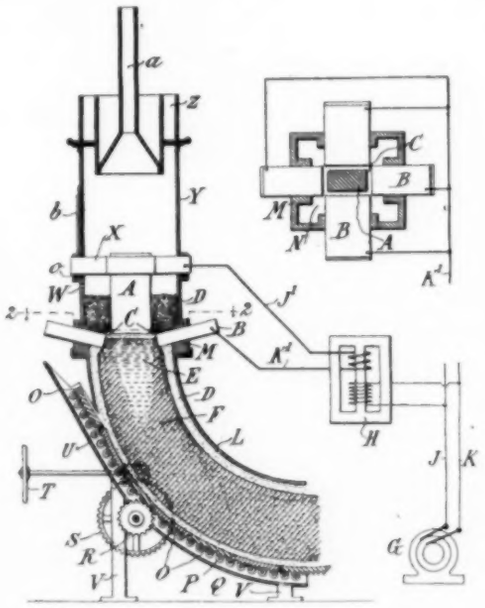


FIG. 2.—CALCIUM CARBIDE FURNACE.

stituting one of the electrodes, and B are the carbon blocks, or sections connected with each other, and constituting all together the opposite electrode. The inner ends of the carbons B are contiguous to each other, so that they form substantially a die surrounding the pencil A. The pencil A is of such size as to leave an annular space C between the opposite electrodes. It is through this annular space, across which the current continually passes, that the material D is passed, and first liquefied into a pool, as shown at E, which subsequently solidifies into a pig F of carbide. A suitable mechanism for drawing out the pig F comprises a conveyer made of sections O connected together to form a continuous curved platform running on rollers P.

Electric Furnace Control.—F. Creelman, 874,944, Dec. 31, 1907. Application filed Jan. 5, 1904. Assigned to Willson Carbide Works Co. of St. Catherines, Ltd.

To operate a furnace with constant power the inventor employs a constant current supply, that is, a constant number of amperes are passed through the furnace while the e. m. f. varies in proportion to the internal resistance of the furnace. The furnace is so regulated by hand or automatically as to restore the normal internal resistance when varied from, so as to maintain an approximately uniform internal resistance, and to thereby maintain an approximately uniform expenditure of energy or generation of heat. Thus in practical operation, whenever the internal resistance varies, the current, instead of varying in inverse proportion, remains constant, and a variation in voltage alone takes place, the normal voltage being soon restored by the regulation of the furnace, which restores the normal resistance. This is accomplished in a crucible furnace by lifting of the carbon pencil or pencils; in a rotary furnace by the advancement of the shell carrying the reduced product, commonly in the form of a pig or ingot; or in a horizontal incandescent furnace by the separation of the conducting pencils. With respect to calcium carbide manufacture, the object is to produce the carbide without crust, and the method is similar to that described in the preceding abstract. The process may be described as a continuous tapping process, in which the zone of fusion is maintained in the tap-hole itself, the fused material being supported immediately beneath the tap-hole to uphold therein the material undergoing fusion. In practicing this process the inventor feeds or passes the entire mixture through the zone of fusion and reduction maintained between two electrodes, the interspace between the electrodes constituting the outlet or tap-hole of the furnace, and also constituting the zone of reduction. Preferably one electrode is formed as a pencil projecting into and through an opening formed in the other or annular electrode, the annular space between the two forming the interspace or tap-hole. Since none of the mixture can pass through this interspace or zone of reduction without being reduced, no crust is formed. The use of a constant current supply is necessary for this method, since with the same the electrodes are normally stationary, or are readjusted only at long intervals as they wear away, and wide but momentary fluctuations of resistance are liable to occur, due to variations of the condition of the material filling the interspace or zone of reduction.

Induction Furnace.—G. Gin, 875,801, Jan. 7, 1908. Application filed May 3, 1906.

This is the type of induction furnace to which Mr. Gin referred in his recent American Electrochemical Society paper on the use of the electric furnace for zinc production. The construction is shown in Fig. 3. The main object is to get a strong, continuous circulation of the molten material. This is obtained by forming the channel crucible of a succession of open channels or receptacles, the bottom of each being longitudinally sloping, and by connecting these channels or receptacles by means of laterally closed conduits connecting the deep end of each channel with the shallow portion of the adjacent channel. The continuous channel is indicated in the plan section of the illustration by 1, 2, 3, 4, 5, 6, 7, 8. The connection of 1, 2 and 3 together is shown in the vertical section, which is a section along the line *a b* of the plan section. Since the Joulean heat developed at different points of the circuit changes with the cross-section, temperature differences are produced, and therefore differences of specific gravity, which result in continuous movement. The magnetic circuit E is a double one, and the primary winding F consists of two symmetrical windings placed on the two upper horizontal arms. B and C are the fluid mass, and A is refractory material.

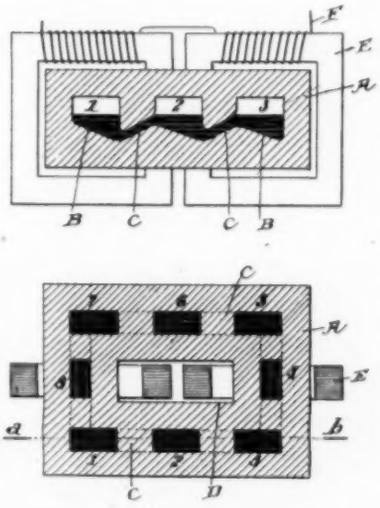


FIG. 3.—INDUCTION FURNACE FOR ZINC SMELTING.

Carbon Bisulphide Furnace.—E. R. Taylor, 871,971, Nov. 26, 1907. Application filed Sept. 5, 1906.

In the present patent, Mr. Taylor endeavors to apply the principle of using self-moving materials in resistance furnaces,

which he has carried out so successfully on a large scale to the construction of a carbon bisulphide furnace on a comparatively small scale. The furnace has an embrasured wall of firebrick, enclosing a vertical working chamber and outer shell, and enclosing an annular feed space between the wall and the shell. Electrode stems extend downwardly within this feed space, and a pair of electrodes is attached to the lower ends of these stems. They extend into the working chamber and toward each other.

Electrolytic Processes.

Electrolytic Production of Cyanides.—F. W. Morris, 871,948, Nov. 26, 1907. Application filed Dec. 28, 1906.

The process consists of two steps, the first of which is carried out in an electrolytic cell of the same construction as the Castner-Kellner cell, the anodic and cathodic compartments being connected together at the bottom by a body of mercury. The difference from the Castner-Kellner cell is that in the present case both compartments are filled with a solution of sodium or potassium formate. The result of electrolysis is the production of formic acid in the anode compartment and of caustic soda with the evolution of hydrogen in the cathodic compartment. When the circuit is broken the formic acid is neutralized by the addition of a suitable ammonium salt for the production of ammonium formate. The latter is siphoned off and is evaporated to form dry crystals or just to the point of breaking off, which point is indicated by the faint smell of hydrocyanic acid being given off. The crystallized ammonium formate is then charged into a still and quickly heated, whereby it is broken up into hydrocyanic acid and water, which are condensed in a worm connected to the still and contained in a water tank. The lower end of the worm leads itself into a receiver, charged with caustic soda or caustic potash (accordingly to whether sodium or potassium formate is used in the original electrolysis). The interaction between the hydrocyanic acid with caustic soda or potash yields sodium or potassium cyanide, respectively.

Electrolytic Refining of Tin.—E. A. Sperry, 874,707, Dec. 24, 1907. Application filed Sept. 15, 1906.

Slag tin, dross tin or other impure tins may be electrolytically refined with an electrolyte consisting either of the sulphate or ammonium oxalate or ammonium sulphide or chloride or fluoride or hydrochloric or hydrofluoric acid. In most electrolytes the objectionable impurities, among them lead, are segregated out from the other impurities and, together with the lead, tend to deposit on the cathode along with the tin, especially at high temperatures. It is recommended to remove as many impurities in advance of electrolysis as possible. For this purpose the impure tin is molten and treated by poling. The dross, which consists in certain oxidation products of lead and also some of the other objectionable impurities, accumulates on the top and is skimmed off. During the poling operation an oxidizing agent, such as a nitrating element, may be added; for instance, saltpetre, which is very gradually introduced into the molten mass to hasten the formation of the oxidation products. It is preferable to pour the anodes at a low temperature. During electrolysis it is important to prevent the anode slimes from reaching the cathodes. For this purpose a diaphragm cell is used. The electrolyte in the anode compartment is circulated. The best temperature of electrolysis is usually slightly below 85° C. The total impurities of the product are well under 0.01 per cent. The impurities accumulate in the electrolyte and are eliminated by periodical withdrawal of portions and treatment and replacing with pure and fresh electrolyte. The treatment in this case may be illustrated in the use of stannous chloride as electrolyte. Here the electrolyte withdrawn is treated with quick-lime or milk of lime, or a suitable alkali, and the tin precipitated as tin oxyhydrate, which is utilized as raw tin oxide, is smelted or is "roasted" and separated or concentrated to eliminate the impurities. The tin may then either be smelted or utilized as fixed oxide; the impurities in whole or part are left behind in the precipitating process. That portion thrown down with the precipitate is eliminated in the roasting or concentrating or separating process.

Production of Aluminium.—H. S. Blackmore, 872,985, Dec. 3, 1907. Application filed April 18, 1903.

Aluminium is reduced from its oxyfluoride or mixture of oxide and fluoride by electrolyzing this mixture in a carbon-lined reduction pot with a calcium carbide anode. The aluminium oxide and fluoride are melted by the current, and its fluidity may be increased by addition of calcium fluoride. The reaction is $Al_2F_6 + 2Al_2O_3 + 3CaC_2 = 6Al + 3CaF_2 + 6CO$, aluminium being set free at the cathode and calcium fluoride and carbon monoxide being liberated at the anode.

Aluminium Alloy for Steel Casting.—M. Meslans, 875,668, Dec. 31, 1907. Application filed July 7, 1902.

A metallic crucible which is connected to the negative pole of an electric circuit has sides covered with a refractory and insulating lining, while the bottom is exposed. The exposed bottom is covered by fused aluminium and above the aluminium is a layer of anhydrous calcium chloride which constitutes the electrolyte and into which carbon rods forming the anodes are suspended. A voltage of from 7 to 10 volts is employed with a current density from 100 to 150 amps. per square decimeter of the anode surface. By the action of the current calcium is set free at the cathode and alloys with the aluminium. The proportion of calcium in the alloy may be regulated at will by continuing the electrolysis for greater or less time. Aluminium-calcium alloys containing up to 95 per cent of calcium may thus be made. When the alloy becomes very rich in calcium, it detaches itself in large pieces and comes up and floats on the surface of the electrolyte, from which it is removed. Alloys of barium, strontium, lithium with aluminium can be made in the same way. Concerning the application of this alloy in steel casting, see the abstract under Recent Metallurgical Patents.

Copper Refining.—F. L. Antisell, 875,641, Dec. 31, 1907. Application filed July 5, 1906.

The inventor proposes to separate the anodes and cathodes in an electrolytic copper refining cell by diaphragms. The object is to prevent any silver from being mechanically carried over from the anode to the cathode. Further, short circuits are prevented. While the diaphragm naturally increases the internal resistance, it is possible to counteract this by placing the anodes and cathodes closer together so that a greater output is obtained from a tank of given size. The diaphragm is made of a frame of vertical and horizontal wooden rods. The open rectangular space is being filled in or paneled with veneer of about 1/28 of an inch in thickness. White wood rotary-cut veneer forms a satisfactory material for the panels. The panels are preferably so constructed that the grain of the veneer runs vertically. The circulation of the electrolyte is maintained by feeding it into the tank at one end, circulating it through the tank and running it off at the other end.

Camphor.—C. Glaser, 875,062, Dec. 31, 1907. Application filed Jan. 26, 1906.

Isoborneol, borneol, camphene are oxidized to camphor by electrolyzing a 2½ to 5 per cent sodium chloride solution in a diaphragm cell, the isoborneol or other camphor-producing substance being placed on top of the electrolyte in the anode room. A current density of about 1 amp. per square centimeter of cathode is used. Heating accelerates the action. About forty parts of sodium chloride are sufficient for 100 parts isoborneol, but it is advantageous to employ an excess of sodium chloride. Since the latter is largely regenerated after the current is stopped, it is possible to produce large

quantities of camphor with a given quantity of sodium chloride.

Anode for Electric Cyanide Process.—R. J. Wisnom, 872,878, Dec. 3, 1907. Application filed Oct. 3, 1906.

The anode shown in Fig. 4 consists of a sack of canvas 1, with vertical lines of sewing 2 extending to within a short distance of the top, thus dividing the sack into a number of vertical pockets, connected at their tops to a horizontal transverse pocket. The pockets are packed tightly with lead peroxide in granular form. A conducting wire 3 is placed in the horizontal pocket, and the granular filling is pressed tightly in contact therewith by strips of wood 5 on each side of the pocket. Vertical strips 7 are fastened to one or both sides of the bag 1 to prevent it from sagging out of shape.

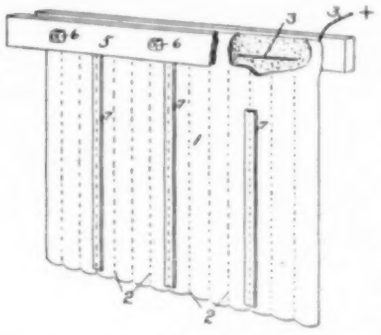


FIG. 4.—ANODE FOR CYANIDE PROCESS.

Mercury Cathode for Metal Deposition.—W. A. Hendryx, 866,859 Sept. 24, 1907. Application filed June 30, 1905.

This cathode is intended specially for depositing gold, silver and copper from their cyanide solutions, and is shown in Fig. 5 in vertical and horizontal cross-section. A wooden frame 1 has a bottom 2 on which is placed a perforated plate 3 of cement or terra cotta. On this rests a filtering medium 4, like sheets of asbestos, and upon this the cathode 5 is placed, which consists either of mercury or of granulated lead and mercury or granulated zinc and mercury. Upon the cathode other sheets 6 of filtering material are placed, on which rests another perforated plate 6A like the perforated plate 3. By the clamping strips 7 the whole arrangement is held in position. This cathode is specially adapted for use in the inventor's cyanide process, the solutions percolating or filtering through the cathode envelope, and their metallic values being deposited on the mercury.

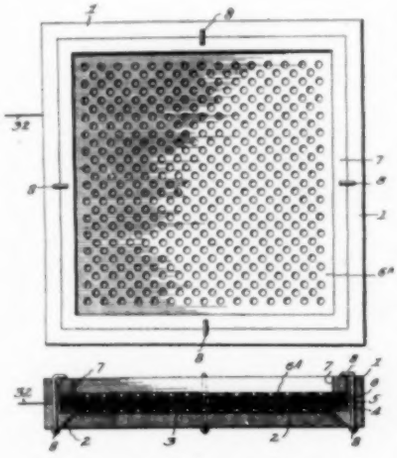


FIG. 5.—MERCURY CATHODE.

Electrolytic Production of White Lead.—F. W. Morris, 871 947, Nov. 26, 1907. Application filed Dec. 28, 1906.

As in the patent dealt with in the preceding abstract, an electrolytic cell of the Castner-Kellner type is used, the two compartments being filled with sodium or potassium formate and connected at the bottom together by a body of mercury. Both the anode and cathode are made of lead. In the anode compartment lead formate and formic acid are formed and spongy lead and caustic soda or caustic potash in the cathode compartment. The current is then cut off and the spongy lead is shoveled from the cathode compartment into the anode compartment, where it is dissolved by the remaining free formic acid and produces lead formate. The presence of the formic acid, which dissolves the lead but does not alter the mercury, prevents the amalgamation of the spongy lead with the mercury. The lead formate thus produced is siphoned out of the anode compartment into a tank, where it is associated with an alkali carbonate, such as ammonium carbonate, causing the precipitation of carbonate of lead, which settles to the bottom while the ammonium formate is drawn off as a valuable by-product. The carbonate of lead is substantially pure, "and will serve all the requirements for which the hydrate of carbonate or white lead of commerce is used"; but if hydrated carbonate is wanted ammonium hydrate is associated with the ammonium carbonate in the required proportion in the settling tank when a hydrated carbonate of lead is precipitated instead of a pure carbonate.

Tin Plating Iron Sheets.—H. L. Hollis, 827,063, Nov. 26, 1907. Application filed May 22, 1906.

The patent refers to mechanical details of supporting and conveying mechanism for use in electrolytic tin plating of iron sheets. A number of the plates to be treated is first stacked in a rack frame, and then a gripping frame, forming part of the conveying apparatus, is brought into position over the plates and clamping means brought into clamping engagement with the individual plates, whereupon the gripping rack with the supporting plates is raised by suitable tackle mechanism and conveyed on a trackway to a position above the electrolytic tank, whereupon the plates to be treated may be lowered in proper position with respect to the other plates in the tank. Supporting and guiding means are also provided on the gripping frame which engage about the plates to be treated to hold them in proper spacing when removed from the rack and when inserted into position between the other plates in the plating tank.

Cleansing Metal.—J. Hawthorne, 871,994, Nov. 26, 1907. Application filed March 26, 1907.

To clean gold and silver articles, they are placed in a tin or aluminium dish, filled with a comparatively weak but hot solution of soda ash, consisting of 97 per cent sodium carbonate, 0.75 sodium bycarbonate and 0.80 sodium chloride. The gold or silver article forms with the tin or aluminium dish a short-circuited galvanic cell, and any oxides or sulphides on the surface of the articles are reduced to metal by electrolytic action. The soda ash also acts on fat and grease which may be on the surface. Since the action is the reduction of the oxide or sulphide to metal no silver or gold is lost from the surface of the articles.

Ship Bottom Protector.—J. H. Schoneberger and G. W. Frazier, 872,759, Dec. 3 .1907. Application filed Sept. 14, 1906.

The metal bottom of the vessel is unpainted, and is made the cathode in an electrolytic cell whereby the sea water is electrolyzed and hydrogen and sodium hydrate are set free on the cathode. This is claimed to protect it from the ordinary attacks of vegetable barnacles, mollusks or insect parasites.

BATTERIES.

Storage Battery.—T. A. Edison, 873,220, Dec. 10, 1907. Application filed Nov. 23, 1903. Assigned to the Edison Storage Battery Co.

In order to improve the output of his nickel-iron battery and to reduce the swelling of the active nickel mass in the nickel-plated perforated pockets in which it is maintained under pressure, a small proportion (15 per cent) of bismuth hydroxide is intimately mixed with nickel hydroxide and applied to the surfaces of flake graphite.

Storage Battery Grid.—J. Mark, 873,382. Dec. 10, 1907. Application filed Jan. 2, 1907.

The second claim refers to a grid "consisting of a frame provided with a series of spaced parallel and horizontally extending bars, and two sets of obliquely extending ribs on opposite sides of said bars, the said ribs of each set intersecting each other, and the said ribs being V-shaped in cross-section."

Storage Battery.—Q. Marino and E. W. Barton-Wright, 873,132, Dec. 10, 1907. Application filed Dec. 17, 1906.

What the inventors claim is: "In electric accumulators having the positive and negative plates supported horizontally and alternately one above the other, the combination therewith of separating boards of specially treated wood placed between the said plates and lines on each side with a layer of specially treated wood fibers, a hole or holes formed in each plate and board in line with each other, a raised rim forming the edge of each hole. so as to provide a continuous passage or tube running vertically through the said plates and boards, and a vertical screw-threaded rod fitted within and passing through each of the said passages or tubes for effecting the escape of the expanded gases."

Storage Battery.—H. Rodman and G. M. Howard, 875,213. Dec. 31, 1907. Application filed Dec. 22, 1905. Assigned to Electric Storage Battery Company.

Distinct advantages (a characteristic loose structure, uniform capacity, prolonged life) result from the incorporation with the active material or lead oxide of the negative pole plate of a storage battery of an inert finely divided material insoluble in the electrolyte. The material employed by the inventors is an insoluble sulphate, preferably sulphate of barium. This is precipitated from a cold solution of a soluble salt of barium by the use of sulphuric acid and is obtained in a state of exceedingly fine subdivision. It is mixed with the lead oxide in proportion of about 5 per cent by weight.

Battery Connection.—G. P. Blow, 873,660, Dec. 10, 1907. Application filed April 11, 1907.

The object is to do away with all screw connections and binding posts on dry cells. The inventor uses a zinc container, "a notch from the side of said container, a carbon element with a ball-shaped end. a connection passing through said notch and insulated from said container, resilient lips on said connection for embracing the ball-shaped end of said carbon element and a resilient member on said connection external to said container."

Discharges Through Gases.

Bleaching and Sterilizing.—S. Leetham, 854,508, May 21. 1907. Application filed July 16, 1904.

To bleach flour, sterilize milk, etc., the use of air is recommended, which is first passed through a silent discharge to change the oxygen into oxone and then through a spark discharge to produce nitrogen oxides and probably other effects in addition. This method is more effective than either treatment alone or carrying on the two steps in the reverse direction.

Miscellaneous.

Electrotherapeutic Apparatus.—N. H. Raymond and J. C. Vetter, 872,148, Nov. 26, 1907. Application filed Aug. 24, 1905.

Details of construction of an apparatus consisting essentially of two parts, which are held in the two hands and are applied to such parts of the body which it is desired to treat electrically. One part contains a dry cell, the other part an induction coil and interrupter. The action is controlled by movements of the thumbs of each hand.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Titanium-Nickel-Chrome Steel.—J. Churchward (867,642, Oct. 8, 1907) patents an alloy steel which is claimed to be particularly hard and tough and to have high tensile strength. It consists of 96.0 per cent by weight of steel (containing 0.5 per cent of carbon), 1.0 titanium, 0.5 chromium, 2.0 nickel and 0.5 manganese. The preparation of this steel offers a difficulty on account of the very high melting point of titanium, since it is important in mixing to prevent chilling. For this purpose manganese is said to be necessary. The titanium is melted in a crucible at a temperature believed to be about 3,000° C., and the steel, nickel and chromium are melted in another crucible and heated to a point just below the point of volatilization. The manganese is then added to the molten titanium, and while it is being melted and incorporated with the titanium. the molten nickel-chromium-steel alloy from the other crucible is brought into the crucible containing the titanium. The nickel is said to impart toughness, the chromium hardness and the titanium to increase both hardness and toughness.

Treating Blue Billy.—Blue billy is a by-product from the treatment of pyrites. and contains a high percentage of iron, and is comparatively low in impurities, notably in phosphorus, but it is difficult to handle on account of its refractory nature. J. G. Bergquest (877,394, Jan. 21, 1908, assigned to American Sintering Co.) proposes to mix blue billy and flue dust in about equal proportions together; the flue dust serves in the mixture to flux the blue billy and the blue billy serves to prevent adherence of the clinker to the furnace walls. The following comparative analyses of flue dust and blue billy show the approximate compositions of each; these analyses being each characteristic:

	Flue Dust.	*Blue Billy.*
SiO_2	8.00	3 to 4 per cent.
Al_2O_3	2.00	
CaO	2.50	trace.
MgO	1.00	
Fe	48.00	62 to 63 per cent.
Coke dust	16.00	None.
Sulphur	.27	1.0 to 2.0 per cent.

It will be seen that the blue billy is composed almost entirely of oxide of iron, which in a pure state is practically infusible at all ordinary furnace temperatures, while on the other hand the flue dust contains considerable percentages of lime, silica and aluminium and a relatively large percentage of coke. The fusing point of the mixture is lowered to a degree well within the range of ordinary reducing furnaces. The inventor uses an inclined rotary furnace of the general type used in making Portland cement, the mixture of blue billy and flue dust being fed into one end and gaseous or pulverized fuel being blown into the other end.

Alloy for Iron and Steel Casting.—Bubbles and blowholes in ingots of cast steel are chiefly due to the presence of three gases, oxide of carbon, hydrogen and nitrogen. By adding a small quantity of aluminium in the moment of casting the oxide of carbon is removed. The hydrogen and nitrogen may be removed by employing such metals as calcium, barium, strontium and lithium. It is preferable to employ these metals alloyed with aluminium so that all the gases are simultaneously removed. An alloy of aluminium and calcium, or of aluminium and barium, etc., may thus be employed. Concerning the method devised by M. Meslans (875,668, Dec. 31, 1907) for making such alloys, see abstract under Analysis of Current Electrochemical Patents.

THERMIT PROCESS.

Modifications of Aluminothermic Reaction.—Dr. Hans Goldschmidt's exceedingly useful aluminothermic method is essentially based on the high oxidation heat of aluminium. Extended researches have been carried out by the inventor, in recent years, to determine whether other elements with a high oxidation heat could be substituted for aluminium in his process. Calcium and silicon have been proposed and tried. As mentioned in his recent patent (875,345, Dec. 31, 1907) it has been more and more clearly borne out by these experiments that for technical reasons calcium alone is not suitable, while silicon alone or silicon mixed with aluminium had before been found to be unsuitable. These experiments have, however, established the fact that a calcium-silicon mixture or alloy or a calcium-aluminium mixture or alloy give high thermic effects. The use of an alloy has an advantage over the mixture in so far as it is more resistant against the atmosphere. The employment of a calcium-aluminium mixture renders possible the production of a thinly liquid slag, to which, by an addition of other substances, the property of "sintering" can be given, so that it becomes possible to use this mixture for all the known applications of the Goldschmidt thermit process. When mixing aluminium with iron oxide and bringing this mixture to reaction, the resulting molten iron is superheated to such a degree that a quantity of iron equaling about one-third the total weight of the mixture may be added, and still the iron, as well as the slag, will be perfectly liquid. If a mixture is prepared of calcium, with an equivalent quantity of iron oxide, and again metallic iron to the amount of one-third of the weight of the mixture is added, a "sintering" mass is obtained, partly on account of the production of a slag which fuses with difficulty. If, however, a mixture is made of aluminium and calcium, intimately mixed with iron oxide or iron-oxide-protoxide, in the manner of the Goldschmidt thermic process, the thermic effect is considerably increased, and iron weighing two-thirds of the total weight of the mixture can be added without causing the slag to solidify or the iron to become sluggish. The greatest efficiency and the quietest reactions are generally obtained with mixtures composed in such a way as to give "the most possibly thinly liquid slag": a thinly liquid aluminate is calcium-aluminium-oxide ($3CaO_2Al_2O_3$). This is actually obtained by mixing together about 60 per cent of an equivalent mixture of aluminium with iron oxide or oxydulated iron, respectively (so-called "thermit"), and 40 per cent of an equivalent mixture of finely divided calcium and iron oxide; this nearly exactly corresponds with an alloy of equal parts of calcium and aluminium (to be exact, 49 Al51Ca). As regards calcium-aluminium-silicium-thermit a good result and a highly thinly liquid slag are yielded by a mixture of metals, which, after the reaction, leaves a slag of the following composition: Calcium-aluminium-silicon-oxide ($3\ CaO.Al_2O_3Si.3O_2$), and which accordingly would have to consist of 50 parts aluminium-thermit, 70 parts calcium thermit and 100 parts silicon thermit. Still the caloric effect is lower than that of the old aluminium-thermit (about 75 per cent), but the mixture is still suitable for technical purposes, especially for welding. Concerning further details, reference must be had to the patent, which contains a great deal of information concerning the behavior of various mixtures of alloys.

COPPER.

Converting Copper Matte into Blister Copper.—J. D. Burgess, of Tucson, Ariz. (877,292, Jan. 21, 1908), wants to substitute the apparatus shown in Fig. 1 for the "ponderous" converters now used in bessemerizing copper matte. The copper matte is taken from the matting furnace V in molten condition and is carried through a series of three inclined boxes B, B^1, B^2. Each steel box is 15 feet in length, 2 feet square on the outside and lined with firebrick, leaving an inner circular or oval opening extending from end to end. Tuyeres extend into the sides of the box, being disposed at an angle pointing downwardly and toward the discharge end of the box. In all boxes compressed air is supplied through the tuyeres. In the first box the reaction is $2FeS + 3O_2 = 2FeO + 2SO_2$, and the air blast also accelerates the flow of the liquid matte through the box. The desulphurized matte is discharged from the first box B into the second Box B^1, and simultaneously silicia is introduced from the hopper P through the open-top spout Q, while the hood U carries away the gases evolved during the conversion of the matte. In the second box, through introduction of the silica and through admission of compressed air through the tuyeres, the reaction $FeO + SiO_2 = FeOSiO_2$ is produced. The mass then flows into the third box B^2 and through the hopper P simultaneously; finally comminuted limestone mixed with coke dust is fed into the mass. This addition gives greater fluidity to the silicious iron slag, separated from the pure copper in the second box, and the coke dust develops and restores heat lost during the operation. At the end of the third box the blister copper flows by gravity into a receptacle. The slag floats on the top and is skimmed off.

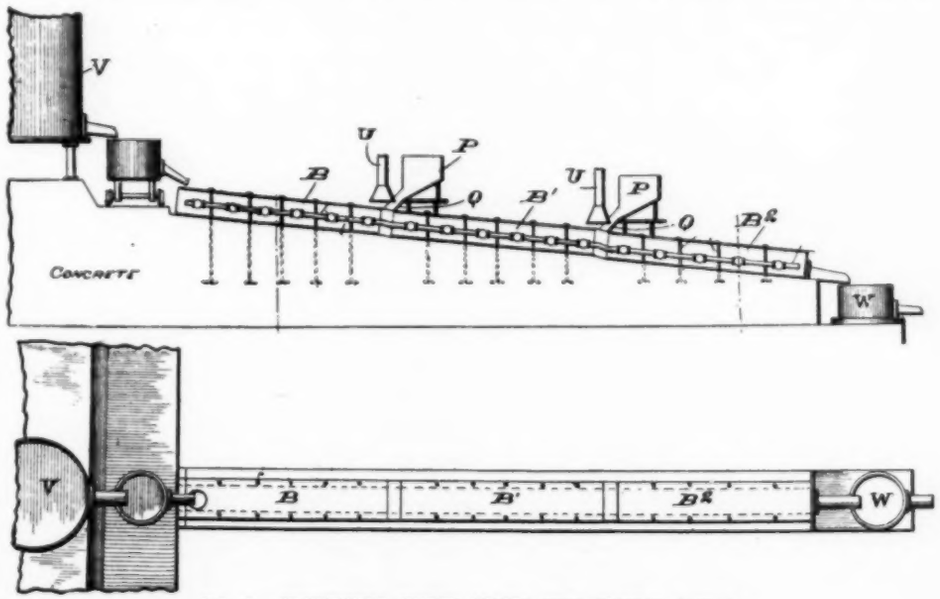


FIG. 1.—CONVERTING COPPER MATTE INTO BLISTER COPPER.

ZINC AND LEAD.

Zinc Oxide.—A patent of H. Pape (877,114, Jan. 21, 1908) describes a method of obtaining oxide fumes from ores and furnace products. The inventor remarks that the well-known Wetherill method of making zinc oxide is useful for certain ores, particularly American franklinite. But if the ore sinters or shows a tendency to melt, this method "cannot be employed, as much too great quantities of zinc are then left behind in the residue." The method described by him is said

to be applicable to every kind of zinc ore or zinkiferous products. The yield is claimed to be so good that, for example, zinkiferous materials may have the zinc removed from them up to 3 per cent or less. The ore or furnace product is disintegrated and intimately mixed with carbon. The ore should be reduced to such granular size that at least 50 per cent of the materials are less than ¾ millimeter (1/32 inch) in diameter. These grains are mixed with carbons in such a manner "that on an average every particle of ore is separated from its neighbor by at least one particle of carbon." The amount of carbon must be sufficient, not only to reduce and vaporize the metal, but also for melting the slag which is formed. After the zinc ore has been mixed with carbon, and such additions as may be necessary, like lime and sand, an agglutinant (cement or disintegrated coal-tar pitch) is added if the mixture in itself is not in a condition to become sufficiently hard after it has been pressed together. The mass is then molded into briquets, either by means of a press or in a suitable sintering furnace. The briquets are fed from above into a furnace, while a powerful current of air is passed through the charge by means of a blast, or by suction, and is regulated in such a manner that the charge is heated to at least a red glow up to its upper surface. The products which are newly thrown on to the charge catch fire and glow on the upper surface, and the metallic vapors which rise up from the lower part of the charge burn to oxides at the upper surface of the charge. Air is preferably admitted in the melting zone, in which there must be incandescence when working up zinc ores, and a quantity of coke in pieces or lumps is added to the charge, so that the necessary temperature is certainly maintained in the melting zone. When the briquets arrive in the melting zone in an already semi-plastic state, the zinc compounds which are in the briquets in direct contact with carbon are decomposed, and the zinc vapors which form, burn to zinc oxide again above the melting zone. At the high final temperature, which characterizes this process, a sintering together of the grains of ore from which the zinc is removed is prevented from taking place, and the same always become molten. By the separate melted grains flowing together, dross is finally formed, which is blown out from the lower part of the furnace in the usual manner. The heat of the gases of combustion which carry away the volatile metallic oxides which are formed in the furnace may be employed in suitable manner; for example, for drying ores, or for heating steam boilers. Other metals which are reduced, but do not vaporize, pass into the slag.

Tin.

Detinning with Chlorine.—Three patents of Elmer A. Sperry (872,092, Nov. 26; 873,699, Dec. 10, and 875,632, Dec. 31) refer to this process, which at present attracts so much attention. The necessity of using absolutely dry chlorine and the difficulties of getting and maintaining it in this condition are pointed out, and it is stated that these difficulties may be overcome by treating the ordinary commercial chlorine with anhydrous stannic chloride. Commercial chlorine contains usually air, carbon dioxide and moisture. This gas mixture is at first chilled or refrigerated to throw out as much as possible the moisture and is then treated with anhydrous stannic chloride. The anhydrous stannic chloride stands ready to take up any moisture or water which may be present or which later may be introduced. The stannic chloride hydrate is an active agent in detinning as it takes up tin to form stannous chloride, which quickly is transformed to stannic chloride through the action of the chlorine present. The iron scrap thus obtained should undergo further treatment, especially if it is to be stored. Though the scrap may be comparatively dry, still there is a tendency to the presence of ferric chloride, either in the form of spots, specks, powder or a coat on the surface. This material is hydroscopic even to the point of deliquescence, and the water attacks the iron, breaking up into the oxyhydrate, etc. The treatment of the iron scrap, which Mr. Sperry proposes, is first washing the iron with water under agitation. "The treatment is then concluded by throwing the scrap into the alkaline reaction or coating same by any suitable material; for instance, silicate of soda or by a solution of sodium hydrate."

Alloys.

Anti-Friction Bearing Metal.—M. C. J. Reed, of Philadelphia (874,866, Dec. 24, 1907), has obtained an alloy of 85 per cent lead, 10 per cent arsenic and 1 to 5 per cent copper, which is stated to give good results as an anti-friction bearing metal. For bearings for certain uses the proportion of arsenic may be very much greater and may in some cases advantageously be increased to 50 or even 70 per cent. In preparing the alloy, particularly where the proportion of arsenic is relatively high, it is advantageous to melt the elements together in a receptacle while under greater than atmospheric pressure so as to prevent volatilization. For anti-friction bearings the copper may in some cases be dispensed with and the arsenic and lead be combined by melting.

SYNOPSIS OF PERIODICAL LITERATURE

Specific Heats.

Carbon Dioxde, Steam and Nitrogen.—Prof. L. Holborn and F. Henning have determined at the German Reichsanstalt the specific heats of nitrogen, carbon dioxide and steam up to 1 440° C. The full account is given in *Annalen der Physik.*, Vol. XXIII., p. 811; an abstract in London *Engineering*, Jan. 3. The mean specific heats c_m between the temperatures O and t degrees C for nitrogen and carbon dioxide and the mean specific heat of water vapor between temperature 110 and t degrees C, are given by the following formulas. The results for steam may be fairly well expressed by two formulas; the one a quadratic formula, would yield a minimum at 190°, which the other exponential formula does not indicate:

Nitrogen—

$$c_m = 0.2350 + 0.000019t.$$

Carbon dioxide—

$$c_m = 0.2010 + 0.0000742t - 0.000000018t^2.$$

Water vapor—

(1) $c_m = 0.4669 - 0.0000168t + 0.000000044t^2.$

(2) $c_m = 0.4544 + 0.006925 \times 10^{0.0073121t}.$

The observed values for steam differ from those calculated by these two formulas in no instance by more than 1.1 per cent. In the following table the final values are given of calculated mean specific heats c_m and the calculated true specific heats c_w. The c_m for water vapor refer to formula (2). The values c_m are mean values of specific heat between O° (or 110°) and t°, as explained above. The values c_w are the actual values of the specific heat at the temperature t.

t Deg. Cent.	Nitrogen.		Carbon Dioxide.		Water Vapor.	
	Cm.	Cw.	Cm.	Cw.	Cm.	Cw.
[0]	0.2350	0.235	0.2010	0.201	0.4613	0.460
200	0.2388	0.243	0.2151	0.229	0.4642	0.466
400	0.2426	0.250	0.2278	0.250	0.4682	0.475
600	0.2464	0.258	0.2390	0.271	0.4740	0.491
800	0.2502	0.265	0.2491	0.285	0.4820	0.515
1000	0.2540	0.273	0.2572	0.295	0.4935	0.554
1200	0.2578	0.281	0.2641	0.301	0.5090	0.614
1400	0.2616	0.288	0.2696	0.303	0.5323	0.707
[1600]	0.2654	0.296	0.2736	0.300	0.5646	0.849

The values for [O] and [1,600] deg. Cent. are extrapolated.

IRON AND STEEL.

Reduction of Iron Oxides.—Schenk, Semiller and Falcke, in the *Berichte der Deutschen Chemischen Gesellschaft*, 1907, P. 1,704 (*Stahl und Eisen*, Sept 4), have investigated experimentally the equilibrium between CO, CO_2, Fe, FeO and carbon. Their results are as follows:

I.

System: Fe, FeO, C (amorphous), CO, CO_2.

Temperature, °C....	556	596	651
Pressure, m.m.....	137	296	571
Gas, per cent CO....	53.7	55.5	57.9
per cent CO_2....	46.3	44.5	42.1

II.

System: Fe, FeO, C (graphite), CO, CO_2.

Equilibrium was much more slowly reached, taking at 650° C. three days.

Temperature, °C....	660	700	...
Pressure, m.m.....	129	360	...
Gas, per cent CO ...	59.6	60.4	...
per cent CO_2....	40.4	39.6	...

III.

System: Fe_3C (cementite), FeO, C (amorphous), CO, CO_2.

Temperature, °C....	672	722	774
Pressure, m.m.....	131	298	562
Gas, per cent CO....	86	87.5	89.5
per cent CO_2....	14	12.5	10.5

From this latter result it follows that cementite is much more easily oxidized than metallic iron. The equilibrium reaction is:

$$Fe_3C + 4CO_2 \rightleftarrows 3FeO + 5CO.$$

These considerations make it appear probable that a gas containing at least 96 per cent of CO is necessary in order to form cementite and thus to carburize metallic iron; but iron oxide, on the contrary, can be converted into cementite with lower proportions of CO.

From the course of the reaction the authors calculate the heat of formation of Fe_3C at 650° to 700° as

$$(Fe_3, C) = 8{,}940 \text{ Cal.}$$

Thermit Process in Iron and Steel Metallurgy.—Two recent publications discuss two different and important applications of thermit in iron and steel metallurgy. In a Franklin Institute paper (*Journal of the Franklin Institute*, July 1907, recently reprinted by Goldschmidt Thermit Company) A. Obholzer reports on the methods used to avoid piping in heavy ingots in the Hungarian Government steel foundries at Diosgyur. For the principle of this process see our Vol. I., p. 533. It has been found by actual experience in the foundries named, that when sinkheads are employed and a charge of thermit is introduced, by fastening a box filled with thermit tightly to an iron rod and sinking it into the fluid steel, the steel begins to boil up strongly and slag is brought to the surface plentifully. The slag is taken off and more fluid steel is poured in. The heat developed by the thermit reaction causes the steel to remain liquid so that the piping can be filled up from the feeding head. The author points out the advantages of pouring heavy ingots with feeding heads, and states that by this application of thermit they have succeeded to remove piping to a very important extent. The possibilities of the thermit welding process for quick repairs on heavy ordnance are discussed in the *Journal of the United States Artillery*, September and October. It is pointed out that thermit makes possible the carrying out of important repairs on gun carriages and other ordnance in the field. In many cases it may be the means of placing guns in commission which would otherwise be useless, or at least require treatment in a repair shop, before being rendered fit for service. In the Russo-Japanese war, thermit has played an important part in making speedy repairs of warships, particularly on the Port Arthur fleet. General rules are given on making thermit welds and the applications to gun cradle and ship repair are described and illustrated.

Removal of Sulphur in Electric Induction Furnace.—In *Stahl und Eisen* of Nov. 6, A. Schmid discusses the rationale of the removal of sulphur from steel in the electric induction furnace. He does not deny that, on account of the high temperature, which can be produced in the electric furnace, highly basic slags remain fluid and have an increased effect. But he thinks that this is not the complete explanation. He offers the hypothesis that there is a specific effect of the electric alternating current itself, which causes the desulphurization under simultaneous action of oxide ores. The use of oxide ore seems important, as is shown from results obtained by the author at Gurtnellen. The results are given of various furnace runs, in which the author found that the sulphur in the steel bath was greatly reduced, while the slag remained free from, or low in sulphur. What then has become of the sulphur? The author thinks that the sulphur is oxidized by the oxide ore and escapes as sulphur dioxide into the air. He thinks that this is a specific effect of alternating currents and would not take place with direct current, but no proof of this is given.

GOLD AND SILVER.

Cyanide Process.—In the November issue of the *Western Chemist and Metallurgist* Dr. F. W. Traphagen gives a review of the development of the cyanide process and its present condition. A number of interesting early patents are first analyzed, and the present status is then summed up as follows: In the practical application of the process the percolation method should always be used when results justify it. This method is so simple, so easily carried out, and so cheap, that where satisfactory extraction can be obtained by its use it is to be adopted. Unfortunately, however, because of inability to percolate material as received, or of the necessity for grinding in order to make a satisfactory saving, agitation, or preferably, a combination of agitation of slimes and percolation of sands after hydraulic classification into these two products, becomes necessary. Of course, with the various devices for separating solution and slime, the problem of slime treatment is much simpler than in the earlier days of the process, and so much better results are obtainable after finer grinding that, notwithstanding the greater difficulties in handling, the agitation treatment is rapidly extending. As to the selection of a machine for fine grinding, the author thinks that the tube mill fulfills the conditions far more perfectly than any other device. As to slime filters, he thinks that the fault for the present situation should be placed in the United States patent office; in granting a patent, there should be sufficient proof that there was no infringement by it on existing patents. At the present time the treatment of telluride ores seems to have found successful solution in the roasting-cyanidation method, and shortly before the fire which destroyed the Dorcas mill, results were being obtained that left little to be desired. The use of the electric current as an aid to solution of gold and silver has not yet met with marked success in ore treatment, but there are good reasons for believing that with many ores greatly improved extraction could be obtained. In like manner the many suggested oxidizing agents have never been extensively adopted, and when oxygen is needed as an aid to extraction, it is usually added by some method of aeration. Precipitation of values simultaneously with extraction and in the same vessel has also failed of general adoption, mainly because of mechanical difficulties. The most important problem before the metallurgist for solution is now that involved in the treatment of silver ores, for while high percentages of gold may be extracted with little difficulty, silver, on the other hand, with few exceptions, yields very imperfectly to cyanide treatment, the average extraction being somewhere about 50 per cent.

A Modern Method of Lead Burning.

By Cecil Lightfoot, Consulting Engineer.

The use of pure oxygen in place of air not only enables much more perfect combustion and higher temperatures to be obtained than are possible with the hydrogen and air system, but it possesses a still further economic advantage in that either coal or natural gas from the town supply may be employed instead of hydrogen.

The oxy-coal gas blowpipe is constructed on the injector principle, and is now extensively used by lead burners. By its use oxygen delivered under slight pressure from a trade cylinder is caused to draw the gas direct from the ordinary town supply and then eject the mixed gases in the right proportion through the nozzle of the blowpipe. The system is being introduced by The Linde Air Products Co., of Buffalo, and its superiority over the old hydrogen and air system, as regards quality of work, economy and convenience in use is admitted by all who have adopted it. It is suitable for ordinary flat work, horizontal and upright joints, overhead patching and the jointing of ordinary lead piping. Any workman conversant with the hydrogen and air system of lead burning will experience no difficulty in operating the oxy-coal gas blowpipe.

It is estimated that in regard to the question of economy there is a saving of approximately 50 per cent by using the oxy-coal gas system in preference to the old hydrogen-air method of lead burning. There are besides many other advantages, as enumerated here below:

1. The hydrogen generator is dispensed with.
2. The air bellows or pump is dispensed with, and consequently the services of a boy are not required.
3. Instead of having to move a heavy hydrogen generator and bellows from one job to another, it is generally only necessary to move a light cylinder containing the oxygen required.
4. No apparatus to get out of order, involving expenditure, delays and repairs.
5. As neither zinc nor sulphuric acid is used, there is no deleterious matter to be carried through the blowpipe to act injuriously on the lead seam.
6. No preheater or "Fou-Fou" is required on heavy work. The oxy-coal gas flame is so hot that even heavy lead in wet and cold positions can be burned "in situ" without preheating.
7. No gas is generated when the blowpipe is not in use, and consequently there is no waste of gas and no charge to withdraw overnight.

It may be stated that for cases where a supply of town's gas is not available coal gas can also be obtained in cylinders, or the oxygen may be used advantageously with the hydrogen "machine."

Two New Pyrometers and the Application of the Radiation Pyrometer for Determining the Temperature of Molten Iron and Copper.

The two portable pyrometers described in the following article have been devised and are manufactured by Dr. C. B. Thwing, of Philadelphia, Pa. The instrument shown at the top of Fig. 1 is of the LeChatelier thermoelectric type, while the second instrument shown at the bottom of Fig. 1 is a radiation pyrometer, measuring the total radiation like the Fery pyrometer. Perhaps the most interesting feature of the galvanometer is the very complete temperature compensation, which does not introduce any dead resistance into the circuit, so that the galvanometer may be made highly sensitive without requiring any leveling. This contributing to the convenience and portability of the instrument, the weight of which is only 3 pounds.

It is important to correct for a change of resistance of the galvanometer coil, due to temperature changes. With a rise of temperature of 50° F., the resistance of copper increases more than 10 per cent. In order to produce, nevertheless, at all temperatures equal deflections by equal c. m. f's, the following principle is applied in the Thwing instrument. The deflection of the coil in a magnetic field is proportional both to the current passing through the coil and to the magnetic

FIG. 1.—TWO NEW PYROMETERS.

flux. The latter depends essentially on the reluctance of the air-gap and the fundamental idea of the compensation is to automatically decrease the length of the air-gap when the temperature rises, so that any increase of the electric resistance of the copper is just counterbalanced by a decrease of the magnetic reluctance.

Fig. 2 shows the arrangement of the electric and magnetic circuits. The coil rotates about one of its ends in a uniform field between two plane pole pieces. The two magnet arms which are connected in parallel by these pole pieces are

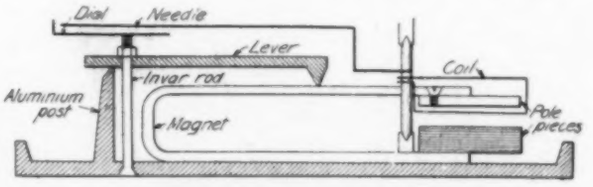


FIG. 2.—COMPENSATION ARRANGEMENT.

very thin and quite flexible. They are pressed together somewhat by the long end of a lever, while the short end rests upon a post which is part of the aluminium case. Near the bearing of the lever on the post and at the proper distance from it, the lever is pierced by a light rod of invar metal, which serves to apply pressure to the magnet. If the temperature of the air rises, the aluminium post expands much more than the invar rod, thus forcing the long end of the lever downward and diminishing the gap between the poles of the magnet by an amount which may be made accurately to compensate for the corresponding increase of the electric resistance in the coil. Different materials are in use for the thermocouples and ac-

cording to Dr. Thwing it is perfectly practicable to dispense with the use of platinum for all ordinary purposes.

The second instrument is, as mentioned before, a radiation pyrometer and consists of a receiving tube and a portable galvanometer. The receiving tube is of light steel oxidized to blackness on its inner surface and is 90 cm. long and 25 mm. in diameter. At the front, or receiving end, a diaphragm determines the angular aperature in conjunction with a conical mirror placed about 70 cm. distant, near the other end of the tube, which is held in the hand when the tube is pointed at the surface whose temperature is to be measured. The radiations are received near the apex of the mirror upon a thin couple of iron constantan, which reaches a state of thermal equilibrium in about 2 seconds after exposure to the radiations. Since all radiations reaching the mirror are transmitted by multiple reflection to the surface of the couple regardless of their direction, the instrument is in focus for all distances. The angular aperature being constant, the indications are independent of the distance of the object so long as the surface is larger than is required to fill the angle.

The galvanometer is pivoted and does not require leveling, thus making rapid work possible in situations where the time required for setting up and focusing a telescope and leveling the galvonometer would be a decided hindrance. The instrument is compensated for temperature variations in the resistance of the moving coil by an automatic variation of the magnetic reluctance as described above in connection with the thermoelectric instrument. This arrangement makes unnecessary the introduction of a dead resistance for swamping the variations due to temperature and permits good control of the needle by the control spring with a fairly high sensibility. Three millivolts is sufficient to produce a full scale deflection of 60°. It is calibrated according to the well-known Stefan-Boltzmann law for total radiation.

This instrument will not measure the temperature of a flame, since the flame is partly transparent and the indication obtained would be almost wholly due to the body beyond the flame. If there are, therefore, hot air or flaming gases between the instrument and the opaque hot body, the temperature of which is to be measured, they will not produce any important change in the readings. Smoky flames will, of course, cut off a part of the radiation and cause the pyrometer to read too low. A light mica window prevents air currents from entering the tube, so that hot or cold currents outside produce no effect on the readings of the instrument. The galvanometer may be quickly placed upon the floor, or a convenient box, as it does not require leveling. Two minutes is ample time to place the instrument and take the temperature of a pot of metal. No focusing is necessary and it is sufficient to simply point the pyrometer towards the body, the temperature of which is to be measured.

The temperature of the contents of a large annealing furnace or of a brick or porcelain kiln is quickly taken by pointing the receiving tube through a peephole at the portion the temperature of which is to be measured. As the tube is less than an inch in diameter a very small hole will suffice. A recorder is attached when desired.

Extended experiments have been made by Dr. Thwing in connection with the measurement of the temperature of molten iron and copper, and some very interesting results were obtained, an account of which was given by Dr. Thwing in a paper recently read before the American Physical Society. From numerous experiments made by him and others to measure the temperature of molten iron by means of the radiation pyrometer it became evident that the results were always obviously much too low. The readings obtained by pointing the telescope at the flowing iron were considerably less than that of the same iron as it solidified in the ladle. This necessitated the conclusion that the emissivity of clean, molten iron is much less than that of a "black body," which solid iron approaches quite closely, and to which the Stefan-Boltzmann law refers.

Dr. Thwing made a series of experiments to determine, at least roughly, the constant of radiation for iron and copper, since the importance of a knowledge of the temperature of these metals in various industrial operations is coming to be recognized by metallurgists to have considerable importance, and the principle of total radiation offers an extremely convenient means of making such measurements.

Comparative measurements were made with the Thwing radiation pyrometer and with LeChatelier pyrometers, the couples of which were enclosed in quartz tubes, and in some cases further protected by iron or graphite tubes. The short life of the couples precluded the making of a large number of observations by their means.

At an iron foundry the iron was drawn continuously from the cupola into a large mixing ladle, whence it flowed under a dam into the pouring ladles. The receiving tube was pointed alternately at the stream flowing into and out of the mixing ladle, while the LeChatelier couple was immersed in the ladle, the temperature measured by the couple being considered the same as the average temperature of the two streams. The fall of temperature in the ladle was about 40°.

At a Bessemer plant the LeChatelier couple was inserted in the 15-ton pouring ladle and the radiation measured from the stream as it issued from the bottom of the ladle. The stream was here certainly free from all slag and oxide. A similar condition was quite fully realized at the iron foundry by pointing at the lower or back side of the stream.

The results are summed up as follows. For cast iron at 1,300° to 1,400° C., the intensity of total radiation from the molten metal was found to be 0.29, and for mild steel at 1,600° to 1,650° C. 0.28 that of the radiation from solid metal at the same temperatures.

Observations made upon open-hearth furnaces within the furnace, where black body conditions obtain, and at the stream as it issues from the furnace, indicate that the value found holds for temperatures up to 1,800°, and there is no evident reason why it should not hold for still higher temperatures.

A smaller number of observations made upon copper gave a value for the emissivity of that metal in the molten state of but half that of iron, or 0.14 that of a black body. The low emissivity of molten copper has been remarked by workmen, who find that molten copper in the ladle burns the face much less than the same copper when cooling in large ingots where the exposed surface is about the same as in the ladle.

Large numbers of measurements of molten iron give concordant results and point to a constancy of the constant for molten metal sufficient to permit of the employment of the same pyrometers as are used for solid metals by the use of a factor or by employing two scales.

A New Heat Gauge or Electric Pyrometer.

The accompanying illustration shows a new heat gauge or electric pyrometer which is a reliable and substantial instrument for shop use. This device is the outcome of some years spent in research work on alloys having a high melting point and giving at the same time an electromotive force sufficiently high to produce a thermocouple that can be used with a more robust portable millivoltmeter instead of the usual delicate galvanometer. The outcome has been a reliable heat gauge for measuring the usual industrial furnace temperatures at a cost that will enable the smallest shop to avail themselves of this great aid to accuracy.

On account of the large diameter of the wires and the metals of which it is made this thermocouple or "hot end" needs no protecting tube, thus doing away with use of expensive and fragile porcelain tubes. At the same time the temperature of

the hot end is then exactly the same as the temperature of the molten metal to be measured. This is especially important in taking the temperature of molten aluminium, which must be poured at as low a heat as is possible.

The Hoskins thermocouple responds quickly and indicates

PYROMETER.

without lag the temperature of the material measured. It is not affected by furnace gases and does not alloy with the non-ferrous metals, such as aluminium and its alloys, brass, zinc, copper, lead, etc. These valuable properties make it safe for use in the foundry, and will enable the founders to repeat with certainty the pouring temperatures that have been found to be best for strength and to make sound castings. In the machine shop it is usual for each tool maker to harden his own work, and because he is called on to do this only when each job is finished he has to depend on his judgment for the proper temperature and try and remember about how hot he heated the last job. The use of a heat gauge eliminates all this guess work and saves many times its cost in a very short time.

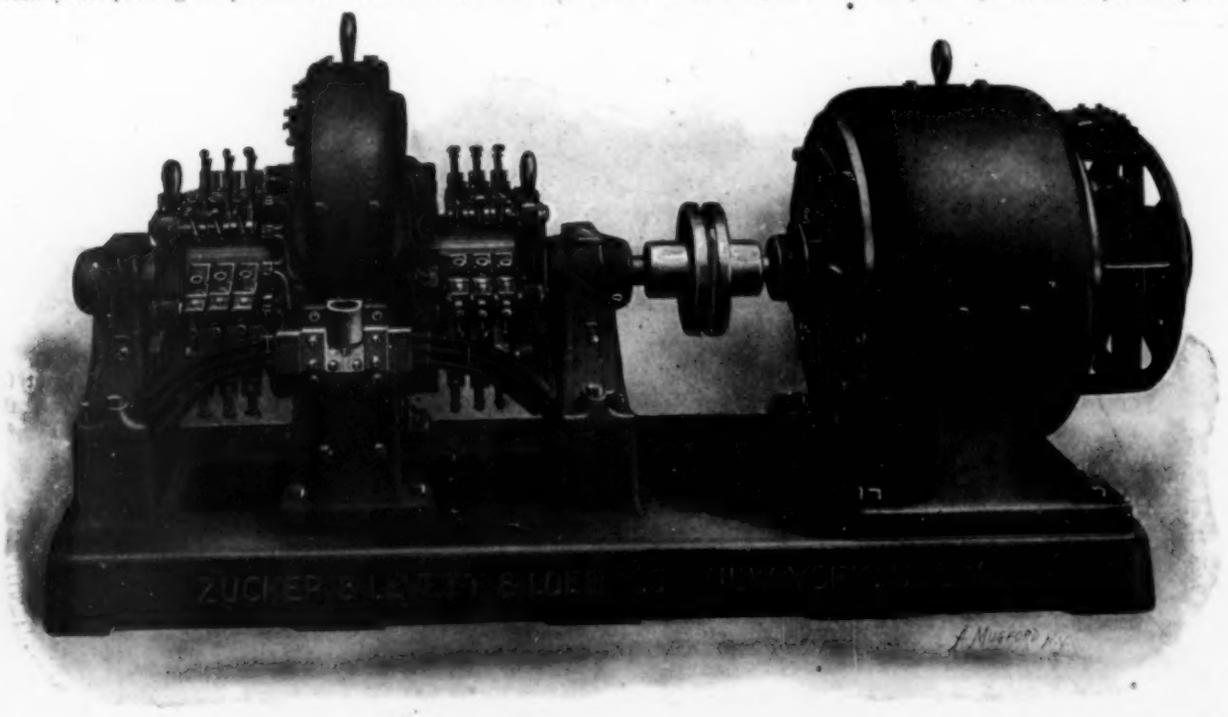
This is well illustrated by the experience of a prominent automobile manufacturer, who states that before he had a heat gauge he employed the highest paid man in his shop to do the hardening. Now he gets better results with the lowest paid man in the shop, who is told to keep his furnace at 750° C., or such other temperature as the work demands.

The Hoskins thermocouple has more than four times the electromotive force of the platinum-rhodium couple, giving 40 millivolts at 1,000° C., as against 9 millivolts for the platinum-rhodium couple.

Bureau of Standards tests show a breakdown point at 1,450° C., and it is guaranteed accurate and durable up to 1,200° C., but may be used occasionally at as high temperatures as 1,400° C. or 2,550° F. Special scales are made for intermediate temperatures. The standard instruments are furnished with the Fahrenheit or Centigrade scales, reading from 400° F. to 2,550° F., or 200° C. to 1,400° C. The Hoskins Co., 93 Erie Street, Chicago, will gladly send a catalogue showing the Bureau of Standards tests with complete information.

Multiple-Voltage Dynamo for Electroplaters.

The adjoining illustration shows a multiple-voltage electroplating dynamo built by Zucker & Levett & Loeb Co., of New York City. As shown in the illustration, this machine has two commutators and two sets of brushes, one on each side of the machine. The two commutators are connected each with one-half of a double winding on the armature. Each set of brushes may be connected to one plating tank, so that two different tanks may be operated from the same machine at the same time, and both may be operated independently of each other, since by placing a rheostat in each circuit it is possible to adjust the voltage impressed at the terminals of each tank at will, independently of the voltage impressed on the other tank. It is further possible by connecting the negative brush on one side of the machine with the positive brush on the other side of the machine, to connect the two armature



ELECTROPLATING DYNAMO.

windings in series, so that at the two free brushes the double voltage is now obtained.

If the machine is built, for instance, to give on each side 5 volts normally, it is possible to supply any voltage between zero and 5 to two tanks simultaneously and independently with the aid of two rheostats. Or by connecting the two voltages in series it is possible to obtain anything between 5 and 10 volts. The savings in floor space and first cost obtainable by this single machine are quite evident.

All these changes are very easily made by means of only three switches. One switch serves for connecting the two windings of the dynamo in series. When this switch is open there is no connection between the two windings, and current is taken off from the two sides of the machine independently of each other and fed to two local circuits. One switch in each of these two local circuits permits to open and close them at will while two rheostats in the same two circuits permit regulating the voltage at will.

The illustration shows this dynamo direct connected to a motor. It is, however, also supplied by the Zucker & Levett & Loeb Co. without the motor, so that they may be driven by belting, etc. These generators are built in capacities from 400 to 10,000 amps.

Portable Heaters for Oil Fuel.

In many cases, work to be heated is too bulky to be brought to the furnace, or for other reasons this is inconvenient or impossible. In such cases it is necessary to bring the heating apparatus to the work. The portable heaters for oil fuel made by the Rockwell Engineering Co., of New York City, prove to be of greatest convenience and usefulness for such purposes, being exceedingly simple to operate. They are made in two types.

SKIN-DRYING WITH OIL HEATER.

The first type is self-contained and must be operated with kerosene or coal oil. In this type the oil is vaporized. The oil consumption is about 2 gallons per hour. The tank containing the oil is provided with a hand-pump, which is used not only for charging the tank with oil but also for obtaining the air pressure (25 pounds). As the air expands only in proportion to the amount of oil consumed it requires little attention. Two hoses with two burners may be fitted to one tank when it is advisable to heat both sides of a heavy object at the same time.

The second type burns crude as well as refined oil, but can be used only where compressed air is available, which is required to atomize the oil. The oil consumption is from 1 to 3 gallons per hour, according to the temperature desired. The size of the flame and the temperature may be changed instantly to suit various requirements by regulating the supply of air and oil. Fifty pounds of air pressure or move will give the best results for high temperatures such as used in brazing, while 10 to 20 pounds of air pressure is ample for skin-drying molds, where a soft, sweeping flame is desirable.

The adjoining illustration shows the application of the Rockwell heater to skin-drying molds, but it is evident that these heaters may be applied for manifold purposes, such as annealing, hardening, expanding, bending, brazing, etc., and should prove useful in boiler shops, shipyards, railroad shops, foundries, etc. Water departments use these heaters for melting lead out of pipe joints.

Notes.

Thermit vs. Weldite.—With reference to the late action of Thermit Limited in London against Weldite Limited for infringement of the former's patent rights for the production of pure metals and for welding metals by the well-known thermit process in which Mr. Justice Harrington, in April last, gave judgment in favor of Thermit Limited, we learn that on Saturday, Dec. 21, an order was made by Mr. Justice Parker, in London, on the petition of Thermit Limited for the revocation of (British) patent No. 10,881 of 1905, granted to Claude Vautin for the process the use of which by Weldite Limited formed the subject of the above action.

Lehigh Valley Section American Chemical Society.—The annual meeting of this section was held on Friday, Jan. 24. Mr. George P. Adamson, of Easton, Pa., reported on the annual meeting of the Society at Chicago. Dr. J. W. Richards, of Lehigh University, spoke on the vapor tension of metals and other substances. Mr. R. K. Meade discussed the systematic keeping of laboratory records. There were twenty-two members present.

Water Power Development in New England.—The development of the Connecticut River Power Co., which has been noticed before in these columns, is now well under way and the company expects to have 16 000 kw. for sale within twelve months. The location of this power, which is in Central New England, makes this development one of considerable importance and value to prospective electrochemical plants, especially as there should be a good demand for certain electrochemical products from various New England industries.

Electric Zinc Reduction in Canada.—In a recent consular report we find the following note from a Canadian newspaper: "The Canadian Zinc Co. is making good progress with the completion of its plant, which should be finished and in operation by the beginning of next February. The plant is designed for electric reduction of zinc, the first of its kind on the continent, although a similar plant is working successfully in Sweden. At the present time much of the lead ore of the Slocan occurs with zinc, and a penalty is demanded by the smelters for zinc units when over 10 per cent. This frequently means that the lead mine cannot be operated because of the zinc penalty and because no values are obtainable for the zinc. The establishment of the Canada Zinc Works in Nelson means the opening up of many idle Slocan properties." Although not stated in this report, it is well known that this plant is the outcome of the endeavors of Mr. Fred T. Snyder. We published a recent paper by Mr. Snyder on electric zinc smelting on page 489 of our Vol. V., and abstracted his patents in our Vol. IV., pp. 152, 319, 503 and in our Vol. V., p. 323.

Calendars.—We acknowledge with pleasure the receipt of a number of pretty calendars. Two different ones were received from the Roessler & Hasslacher Chemical Co.; one is a reproduction of a picture of a fantastic young lady by

Wunnenberg, while the other, with reference to the ferro-alloys handled by this company, is fittingly illustrated by a scene from Schiller's famous poem on the walk to the iron foundry. The pretty girl with a mask on last year's calendar of the National Carbon Co. has changed on the new calendar into a ripe beauty from the brush of Ph. Boileau. The New York Brick & Paving Co. reproduce J. G. Brown's "Attention," a charming picture of a bootblack-boy with his little fox terrier dog. C. W. Levitt & Co. have selected a picture from rural life by F. C. Ransom, illustrating a line fence dispute between two stubborn farmers, while the calendar of the Kny-Scheerer Co. bears their well-known picture of an alchemist in his laboratory.

The business of the late Dr. Peter T. Austen, who died on Dec. 30 after a long illness, will be continued by Mr. Frederick J. Maywald, who has been associated with Dr. Austen and in charge of his laboratories for the past fourteen years. Mr. Maywald is familiar with Dr. Austen's methods, and has had a widely varied experience in all lines of chemical work, all the cases which Dr. Austen undertook having passed through his hands. The offices and laboratories will be located as heretofore at 89 Pine Street, New York City.

Messrs. Byrnes & Townsend, patent lawyers, 918 F. Street. N. W., Washington, D. C., announce that they have associated with them Mr. John H. Brickenstein, former examiner in metallurgy and electricity and late senior member of the board of examiners-in-chief of the United States Patent Office. From Jan. 15, 1908, they will continue the practice of patent law at the above address under the firm name of Byrnes, Townsend & Brickenstein.

Mr. William H. Bristol, manufacturer of indicating and recording pyrometers for all industrial uses, has recently moved his manufacturing departments, formerly located at Hoboken, N. J., and in New York City, to a well equipped factory at Broadway and Giles avenue, Jersey City. The main offices are still located at 45 Vesey Street, New York City.

Welding Flux.—W. A. Barnes, of Wornoco, Mass, has recently obtained a patent for a flux for welding copper. It consists of fine quartz sand, 2 parts; pulverized glass, 2 parts; soft copper filings, 2 parts; borax, 8 parts, and cyanide of potassium, 2 parts. The ingredients are powdered and thoroughly mixed. The pieces of copper to be welded are heated, and are being kept covered with the above flux until white flakes begin to appear on the metal, and as it is then of the proper heat for welding it is hammered.

Chemical Stoneware.—The chemical stoneware business conducted in the past by Messrs. Frederick Bertuch & Co., and under the management of Mr. J. W. Sittig, has been transferred to Mr. Sittig, who is continuing it for his own account hereafter.

American Institute of Social Service.—As a recognition of the honor of decorations bestowed by the French Republic on Mr. Charles Kirchhoff, editor of *Iron Age*, Mr. T. Commerford Martin, editor of *Electrical World*, and Rev. Percy S. Grant, rector of the Church of Ascension, all of whom are members of its board, the American Institute of Social Service gave a dinner at the Aldine Club, New York, on Jan. 15. Hon. Elbert H. Gary, of the United States Steel Corporation, presided. The attendance was above 200. Following a speech of felicitation by Mr. John LaFarge on behalf of the French Consul General, the several honor guests were introduced to the assemblage. Mr. Wm. B. Dickson, vice-president of the United States Steel Corporation, introduced Mr. Kirchhoff; Mr. Frank J. Sprague introduced Mr. Martin, and Bishop Henry C. Potter introduced Mr. Grant. The concluding speech was made by Dr. Josiah Strong, who, in a convincing manner, told of the enormous and unnecessary loss of life, due to the lack of proper recognition of the avoidable risks in our modern industrial enterprises.

Memorial Exercises in Honor of Lord Kelvin.—In honor of the late Lord Kelvin, memorial exercises were held under the auspices of the American Institute of Electrical Engineers on the afternoon of Sunday, Jan. 12, in the "Engineers' Building." Mr. Andrew Carnegie was among the representatives of other national engineering societies which had been invited. President Stott, of the American Institute of Electrical Engineers, was in the chair. The programme included prayer and address by Rev. Dr. Wm. T. Manning, of Trinity Church, adoption of memorial resolutions, introductory remarks by President Stott, and addresses by Prof. Elihu Thomson on Lord Kelvin as an electrical engineer, by Prof. E. L. Nichols on Lord Kelvin as a scientist, by Mr. G. G. Ward on Lord Kelvin's work in submarine telegraphy, by Rear Admiral Geo. W. Melville on Lord Kelvin in naval engineering, and by Mr. T. C. Martin on Lord Kelvin and the American Institute of Electrical Engineers. Three of the speakers referred to the position which Lord Kelvin had taken in the Niagara power question, when he said that Niagara Falls will become truly beautiful only when no longer any water will go over the Falls, but the whole power will be developed and employed for useful work for the best interests of humanity.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

No. 644,510, Feb. 27, 1900. Ellis F. Frost, Washington, D. C.

Feeds charge downward from a hopper having a fireclay mouth into an arc, sprung between the lower end of a vertical carbon electrode, depending centrally within the hopper, and a body of an electrolyte, for example, an aqueous solution of an acid or alkali. The carbid produced in the arc falls into the solution and generates acetylene. Or a layer of the electrolyte may be floated on a body of carbon bisulphide, a heavy hydrocarbon oil, or coal tar. The hot carbid then passes quickly into the next liquid. If coal tar is used, it coats the carbid into a protective layer.

No. 630,690, Aug. 8, 1899. Herman L. Hartenstein, Bellaire, Ohio.

The blast-furnace slag used as a raw material for the production of compound carbides, in accordance with patents 596,704, 596,705 and 596,749, is variable in composition, and is sometimes deficient in calcium. Remedies this by injecting polarized limestone or quickline, carbon and a reducing gas into the molten slag as it is drawn from the furnace, and then subjects the mixture to an electric current, as described in patent 596,749.

656,156, Aug. 14, 1900, William Smith Horry, New York, N. Y.

Calcium carbide is produced in a continuous furnace having special provision for withdrawing the reaction gases directly from the zone of reduction, under such conditions that the finely divided charge is not projected from the furnace and the operation becomes practically dustless. One furnace illustrated comprises a deep vertical casing having a hearth which may be progressively lowered; the electrodes are vertical, disposed entirely within the casing, and are deeply covered by the charge. The casing walls adjacent the electrodes are perforated to permit the free escape of gas, the charge being of sufficient depth to prevent any substantial escape of gas from the top of the casing. In operation a field of reduction is maintained at the top of the finished product and beneath the depending carbons by progressively lowering the hearth, the incoming charge gravitating around the electrodes. A modified construction is described in which the same principle of operation is applied to the rotary or wheel type of carbide furnace.

NEW BOOKS.

JOURNEYS OF OBSERVATION.—By T. A. Rickard. Being the record of a journey from New York to Mexico, together with a description of the mining industry of El Oro, Pachuca and Guanajuato, as observed in October, 1905; also an account of a ride over the mountainous mining regions of Southwestern Colorado in September, 1902. 386 pages; 144 illustrations; 44 drawings. Price, $3.50. San Francisco: The Dewey Publishing Co.

GENERAL FOUNDRY PRACTICE.—By A. McWilliam and Percy Longmuir. Illustrated. Price, $4.50 net. Philadelphia: J. B. Lippincott & Co.

RUST PREVENTION.—By Lionel M. Stern. A treatise on the preservation of structural steel used in bridges, buildings, fire escapes, etc., and sheet steel used in buildings, metal siding, roofing, smokestacks, boiler fronts and standpipes, etc. 54 pages; illustrated. Price, $1.00. Cleveland: Lionel M. Stern.

AN INTRODUCTION TO GEOLOGY.—By W. B. Scott. Second edition, revised throughout. 843 pages; illustrated from drawings by Bruce Horsfall, and from many new photographs. Price, $2.60 net. New York: The Macmillan Co.

MINE GASES AND EXPLOSIONS.—By J. T. Beard. Text-book for schools and colleges and for general reference. 380 pages; 68 illustrations. Price, $3.00 net. New York: John Wiley & Sons.

MINING INVESTMENTS AND HOW TO JUDGE THEM.—By Francis C. Nicholas. This book contains twenty-one chapters, covering such subjects as the organization, financial and physical development of mining properties; the relation of mining stocks to the properties back of them; reasons why mining companies fail, and also why they often succeed. 240 pages. Price, $1.50 net. New York: Moody Corporation.

TECHNICAL METHODS OF ORE ANALYSIS.—By Albert H. Low. Third edition, partly rewritten. Price, $3.00. New York: John Wiley & Sons.

TESTS FOR ORES, MINERALS AND METALS OF COMMERCIAL VALUE.—By F. L. McMeechen. 152 pages; illustrated. Price, $1.25 net. New York: D. Van Nostrand Co.

THE ELECTROLYTIC DISSOCIATION THEORY WITH SOME OF ITS APPLICATIONS.—By H. P. Talbot and A. A. Blanchard. An elementary treatise for the use of students of chemistry. Second edition. 90 pages; illustrated. Price, $1.25 net. New York: The Macmillan Co.

A SCHOOL CHEMISTRY.—By J. A. Waddell. Intended for use in high schools and in elementary classes in colleges. Second edition, revised and enlarged. 303 pages; illustrated. Price, 90 cents net. New York: The Macmillan Co.

QUANTITATIVE ANALYSIS FOR MINING ENGINEERS.—By Edmund H. Miller. Second edition, revised. 159 pages. Price, $1.50 net. New York: D. Van Nostrand Co.

EXERCISES IN ELEMENTARY QUANTITATIVE CHEMICAL ANALYSIS FOR STUDENTS OF AGRICULTURE.—By A. T. Lincoln and J. H. Walton. 233 pages; illustrated. Price, $1.50 net. New York: Macmillan Co.

SPECTRUM ANALYSIS.—By J. Landouer. Second edition, rewritten. 246 pages; illustrated. Price, $3.00. New York: John Wiley & Sons.

PURE FOOD TESTS.—By Edwin M. Bruce. The detection of the common adulterants of foods by simple qualitative tests; a ready manual for physicians, health officers, food inspectors, chemists, teachers and all especially interested in the inspection of food. 91 pages; illustrated. Price, $1.25 net. New York: D. Van Nostrand Co.

TEXT-BOOK OF PHYSIOLOGICAL CHEMISTRY.—By Olaf Hammarsten. Translated from enlarged and revised sixth German edition by J. A. Mandel. Price, $4.00. New York: John Wiley & Sons.

COMPARATIVE ELECTROPHYSIOLOGY.—By J. C. Bose. A physico-physiological study. (This volume concludes the line of investigation on responsive phenomena in general which he began with the publication of a memoir at the International Congress of Science, Paris, 1900. In this first of his publications on the subject he undertook to show the similarities of response in inorganic and living substances. The method which he at that time employed for obtaining his response records was that of conductivity. His researches and observations in other directions, leading to the same results or very similar ones, are here described in detail. Classified list of experiments.) 793 pages; illustrated. Price, $5.75. New York: Longmans, Green & Co.

INDUSTRIAL ALCOHOL.—By J. G. McIntosh. The production and use of alcohol for industrial purposes and for use as an illuminant and as a source of motive power. 260 pages; illustrated. Price, $3.00 net. New York: D. Van Nostrand Co.

SOLUTION TENSION AND TOXICITY IN LIPOLYSIS.—By Raymond H. Pond. (Contributions from the New York Botanical Garden.) 259 pages. Bound in paper. 25 cents. New York: New York Botanical Gardens.

THE METRIC AND BRITISH SYSTEMS OF WEIGHTS, MEASURES AND COINAGE.—By F. Mollwo Perkin. 83 pages; illustrated by diagrams. Price, 50 cents net. New York: The Macmillan Co.

THE WEIGHTS AND MEASURES OF INTERNATIONAL COMMERCE.—By F. H. Hatch and E. J. Vallentine. Tables and Equivalents. 59 pages. Price, 80 cents net. New York City: Macmillan Co.

POWER STATIONS AND POWER TRANSMISSION.—By G. C. Shaad. A manual of approved American practice in the construction, equipment and management of electrical generating stations, sub-stations and transmission lines, for power, lighting, traction, electrochemical and domestic uses. Part 1, Power Stations; Part 2, Power Transmission. 155 pages; illustrated. Price, $1.00. Chicago: American School of Correspondence.

HYDRO-ELECTRIC ENGINEERING.—By H. von Schon. Fully illustrated by original drawings, designs and photographs. Price, $6.00 net. Philadelphia: J. B. Lippincott & Co.

THE ELECTRICAL TRANSMISSION OF ENERGY.—By Arthur V. Abbott. A manual for the design of electrical circuits. Fifth edition, entirely rewritten and enlarged. 705 pages; illustrated by 10 folding diagrams and 16 full-page engravings. Price, $5.00 net. New York: D. Van Nostrand Co.

BOOK REVIEWS.

JOURNEYS OF OBSERVATION. By T. A. Rickard, editor of the *Mining and Scientific Press*. Octavo, 360 pages, profusely illustrated. Price, $3.50. San Francisco: Dewey Publishing Co., 1907.

This is a modern version of the "Metallurgical Journeys" so often written in the nineteenth century. It is a cross between a finely-written book of travel and a metallurgical treatise on silver mining and extraction.

Exactly two-thirds deals with a trip to Mexico by sea from New York to Vera Cruz, and visits to El Oro, Pachucha and Guanajuato; the other third covers a trip across the San Juan Mountains in Colorado. It is sugar-coated metallurgical reading, such as can be done with ease and refreshment when tired after a hard day's work.

The photographs are nearly a hundred in number, and are beautiful; the word-painting is almost equally attractive and artistic; the print is a pleasure to the eye, and the paper completes the list of attractions, being unglazed and restful. The binding is rather too cheap and loud to match the virtues just catalogued.

The breeziness of the "wild and wooly" characterizes some of the author's observations, but his criticisms are not so

harsh as to be repulsive, yet are many times somewhat overdrawn. A little more just and even temper in referring to Wall Street and the capitalists who have done so much to benefit our great West would have drawn the author and his reflecting readers closer together.

Altogether, there is nowhere a better, or half as readable, account in print of metallurgical practice at El Oro, Pachucha, Guanajuato and over the San Juan Range than is here offered in silver-plated literary style.

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Die Eisenhüttenchemie. By Max Orthey. 258 pages; 36 illustrations. Price, 8 marks (retail price in New York, $2.65). Halle: Wilhelm Knapp.

This work aims to be a practical handbook for the use of the chemist in the analysis of iron ores, iron and steel, fluxes, fuels, gases and refractory materials. The taking and preparation of the sample is first given the attention this important matter deserves. Methods of bringing the sample into suitable solution are next treated, after which the qualitative examination for the elements likely to be present is described in detail. On this point it may be said that, for some elements present in small amount, it will require little more time to make a final quantitative determination than is required to make a preliminary qualitative test.

The methods are clearly described in sufficient detail, and the iron chemist will find in the book many useful hints. Apparently, however, the reductor, so indispensable for neat, accurate and rapid work, is not well known in German practice, for in the reduction of the molybdic solution in phosphorous determination, granulated zinc is used in an Erlenmeyer flask, followed by filtration from undissolved zinc in the old, unsatisfactory way.

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Illustrated Technical Dictionary in Six Languages—English, German, French, Russian, Italian, Spanish. Edited after a novel method by K. Deinhardt and A. Schlomann, engineers. Vol. II.: Electrical Engineering, including Telegraphy and Telephony. Compiled by Charles Kinzbrunner, A. M. I. E. E., consulting electrical engineer. 4,000 illustrations and numerous formulas. 2,100 pages. Price, $7.00 net. New York: McGraw Publishing Co.

In our September issue, 1906 (Vol. IV., p. 372), we reviewed the first volume of this new series of illustrated technical dictionaries, which dealt with elements of machinery and machine tools. This is the second volume of this series, and deals with electrical engineering.

The novel arrangement adopted in the first volume is also followed in the second one. The whole volume (2,100 pages) consists essentially of two parts. The first part (1,356 pages) is not alphabetically arranged, but is classified rather like a handbook. It is divided into sixteen chapters, dealing respectively with cells and batteries, boilers and prime movers, electric machinery, switches, measuring instruments, electric supply stations, mains, house installations, lighting, various applications of electricity, telegraphy, telephony, electrochemistry, electromedical apparatus, units of measure and electrophysics, miscellaneous. Each chapter, again, contains the chief technical terms, as much as possible logically arranged. Each word is given in German, English, French, Russian, Italian and Spanish, and extensive use is made of diagrams, formulas and symbols to explain the different terms.

The second main part of the volume (740 pages) contains the alphabetical index of all the terms contained in the first part, with reference to the page where it appears. One index comprises the German, English, French, Italian and Spanish languages, while a separate index is provided for the Russian terms.

All the advantages of this arrangement which we pointed out in our review of the first volume are again evident in the present volume, and it is probably true to say that it is the best electrical dictionary now available. Yet with respect to accuracy this second volume seems inferior to the first. Among numerous other mistakes or inaccuracies we note here only the following:

On page 22, Hg_2SO_4 is given as "mercury sulphate, mercurous sulphate, calomel." The last term is wrong, since calomel is mercurous chloride.

On page 109, Steinkohle, fossile Kohle is translated as "coal, pit coal," instead of bituminous coal.

On page 136, Dreiphasenstrom, Drehstrom is translated "three-phase [alternating] current, triphase a. c. (rotary or rotating current)." It is true the terms "rotary or rotating current" are put into parenthesis, but they are therefore not less ridiculous. Where in all the world have the editors of this dictionary found these terms except in other, older, dictionaries? Did they not intend to improve on the latter? Then they must omit such nonsense.

On page 1,182, "elektrolytischer Wirkungsgrad, Stromausbeute" is translated "electrolytic efficiency." That is very indefinite. Stromausbeute is clearly ampere-hour efficiency.

On page 1,183, "Uberführungszahl des Anions" is translated "coefficient of migration of the anion," instead of the usual terms transference number or transport number.

On page 1,192, the "Bäderraum" of an electrolytic plant is translated into "bath-room." While not directly wrong, it is funny. Let any German come to an American copper refinery and ask for the bath-room, and see whether they take him to the tank-house.

In the first edition of a volume of 2,100 pages, containing nothing but technical terms, it cannot be expected that all are correct. Numerous mistakes will undoubtedly be pointed out to the authors, and we sincerely hope that they will avail themselves of such information to carefully and rigidly overhaul the whole volume for the next edition. For, in spite of all deficiencies, the scheme of the dictionary, in the whole, is so admirable that it should deserve many editions.

* * * *

La Technologia delle Saldature Autogene dei Metalli. By Prof. S. Ragno. 129 pages; 18 illustrations. Price 2 lire (retail price in New York 50 cents). Milano: Ulrico Hoepli.

This little book, forming a volume of the well-known *Manuals Hoepli*, is probably the first monograph in any language on the autogeneous welding of metals. Besides general discussions the following methods are dealt with: Electric welding, welding with the oxyhydrogen, the oxy-acetylene and the oxy-illuminating gas flame, welding with thermit. The intention of the author is to give a general discussion of the essential principles without going deeply into details. As a concise summary of the subject which is now rapidly increasing in interest the little book should be useful.

* * * *

Statistics of the American and Foreign Iron Trade for 1906. Annual statistical report of the American Iron and Steel Association. Philadelphia: The American Iron and Steel Association.

This report gives the complete statistics of the iron and steel industries of the United States for 1906 and immediately preceding years; also statistics of the coal, coke and shipbuilding industries of the United States, immigration, etc.; also more briefly statistics of the iron and steel industries of foreign countries. The following are the final total figures: The total production of pig iron in the United States in 1906 was 25,307,191 gross tons; basic and acid open-hearth steel, 10,980,413; Bessemer steel, 12,275,830; crucible steel, 127,513.